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RESEARCH MEMORANDUM

for the
U. S. Air Force

SPEED-BRAKE INVESTIGATION AT LOW SPEED OF A 1/10-SCALE
MODEL OF THE MX-1554A AIRPLANE WITH A CIRCULAR
JET NOZZLE

By Martin Solomon

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DECLASSIFIED
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DROBKA TO LEBOW
MEMO DATED 12/13/65

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Change Notices No. 43

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SPEED-BRAKE INVESTIGATION AT LOW SPEED OF A 1/10-SCALE

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JET NOZZLE

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SUMMARY

The present paper contains the data of an investigation of the effect of curved speed brakes on the drag characteristics and on the longitudinal stability and control characteristics of a 1/10-scale model of the MX-1554A airplane redesigned to incorporate a circular jet nozzle. The results of two previous investigations of the MX-1554A with a rectangular nozzle and flat-plate-type speed brakes are reported in NACA RM'S SL53A05 and SL53K25. The speed brakes were tested at several deflections, gaps, and locations on the landing configuration and on the clean configuration. Also included in this paper are the results of a short lateral- and directional-stability study undertaken because of the reduction in vertical tail area from that utilized in the previous investigations.

INTRODUCTION

An investigation was made in the Langley 300 MPH 7- by 10-foot tunnel to determine the low-speed drag and longitudinal stability and control characteristics of a modified version of the 1/10-scale model of the MX-1554A airplane with speed brakes. The investigation reported herein is one of several that have been performed for the U. S. Air Force on the MX-1554A project. For this investigation the fuselage had been redesigned to incorporate a circular jet nozzle, curved speed brakes, and a new vertical tail. The results of previous investigations of the model with a rectangular jet nozzle, flat-plate-type speed brakes, and a larger vertical tail are reported in references 1 and 2.

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The present paper contains the results of an investigation of speed-brake effectiveness on the drag characteristics and on the longitudinal stability and control for the brakes at several deflections, locations, and gaps. The investigation was performed for the clean configuration, the landing configuration, and the landing configuration in the presence of a ground board. Also included are the results of a short lateral- and directional-stability investigation undertaken to determine the characteristics of the modified vertical tail.

SYMBOLS

All data are referred to the stability axes as indicated in figure 1. A point of 35 percent of the wing mean aerodynamic chord was used as center of moments. The symbols used in this paper are defined as follows:

C_L	lift coefficient, $Lift/qS$
C_X	longitudinal-force coefficient, X/qS
C_Y	lateral-force coefficient, Y/qS
C_L	rolling-moment coefficient, L/qSb
C_m	pitching-moment coefficient, $M/qS\bar{c}$
C_n	yawing-moment coefficient, N/qSb
X	longitudinal force along X-axis, lb
Y	lateral force along Y-axis, lb
Z	force along Z-axis (lift equals $-Z$), lb
L	rolling moment about X-axis, ft-lb
M	pitching moment about Y-axis, ft-lb
N	yawing moment about Z-axis, ft-lb
q	free-stream dynamic pressure, $\frac{\rho V^2}{2}$, lb/sq ft

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S	wing area, sq ft
\bar{c}	wing mean aerodynamic chord, ft
b	wing span, ft
V	free-stream velocity, ft/sec
ρ	mass density of air, slugs/cu ft
α	angle of attack of fuselage reference line, deg
i_t	angle of incidence of horizontal stabilizer with respect to fuselage reference line, deg
δ	control-surface deflection in a plane perpendicular to hinge line, deg
β	angle of sideslip, deg

$$\left. \begin{aligned} C_{l_\beta} &= \frac{\partial C_l}{\partial \beta} \\ C_{n_\beta} &= \frac{\partial C_n}{\partial \beta} \\ C_{y_\beta} &= \frac{\partial C_y}{\partial \beta} \end{aligned} \right\} \text{lateral-stability parameters}$$

Subscripts:

f flap

SB speed brake

APPARATUS AND METHODS

The model used in the present investigation was a 1/10-scale model of the MX-1554A airplane with a circular nozzle design. The wing and stabilizing surfaces had triangular plan forms with a small amount of sweepback of the trailing edges. The physical characteristics of the model are presented in figure 2. The horizontal stabilizer was constructed with fittings to allow a range of incidences to be tested. The location of the pivot was 47 percent of the mean aerodynamic chord of

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the exposed panel. The model of the present investigation differs from that of reference 2 as follows:

(1) The vertical tail had 19 percent less area and the sweep angle was changed from 65° to 62.5° at the leading edge and from 25° to 15° at the trailing edge (fig. 2.)

(2) The fuselage was redesigned rearward of station 39.75. Instead of a maximum width (plan view fig. 2) of 5 inches as was on the previous model, the fuselage increased in width rearward of station 39.75 to a maximum of 5.86 inches at approximately station 80 and then tapered off to a circular section of 5 inches in diameter at station 87.6. (Station 0 was located at the nose of the fuselage and station 87.6 was at the rear.)

(3) The speed brakes were redesigned to a shape similar to that of the external shape of the fuselage in the vicinity of the speed-brake location. The same speed brakes were used in the forward and rearward positions. (The details are given in fig. 3.)

Photographs of the model mounted in the tunnel in the landing configuration are given in figure 4.

As in previous investigations (refs. 1 and 2), the model had no internal ducting to delay separation which would ordinarily occur from the sharp edges of the scoop; modeling clay was used to refair the throat and edges (fig. 2).

TESTS

The tests were run in the Langley 300 MPH 7- by 10-foot tunnel at a dynamic pressure of approximately 50 pounds per square foot corresponding to a Mach number of 0.184 and a Reynolds number, based on a wing mean aerodynamic chord of 17.93 inches, of 1,850,000.

A ground board was used for some tests to simulate the airplane in the presence of the ground. The relative position of the model and the board is shown in figure 2.

For both the flap-retracted and flap-deflected ($\delta_f = 50^\circ$) conditions, the speed brakes were deflected through a range of 0° to 50° at both a forward and rearward location and with gaps between the brake and fuselage of 0.30 inch and 0.60 inch. The angle-of-attack range was -2° to 22° except where the ground board limited the positive range to 12° . The range of horizontal stabilizer incidence was from -15° to 5° . Lateral-stability parameters were obtained from pitch tests at angles of sideslip of 5° and -5° .

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CORRECTIONS

The angle of attack and drag have been corrected for jet-boundary effects computed on the basis of unswept wings by the method of reference 3. The correction to pitching moment due to tunnel induced upwash at the tail was found to be negligible.

Tare corrections from the model single support strut were not applied to the data. The relative magnitude of these corrections may be obtained from reference 2.

The data have been corrected for the effects of air-flow misalignment and the longitudinal pressure gradient in the tunnel.

PRESENTATION OF RESULTS

Unless otherwise stated in the legends of the figures, the model configuration with the flaps retracted (clean configuration) had the landing gears retracted and all gear doors closed. With the flaps deflected (landing configuration), the main landing gear and nose gear were extended and the landing gear doors were closed with the exception of the nose gear door. The wing had leading-edge notches and fences (fig. 2) for all configurations except for the lateral-stability tests.

In order to facilitate earlier publication of this paper, no discussion or conclusions have been attempted. However, this paper contains all the pertinent results of the investigation of the MX-1554A airplane with a circular jet nozzle and the results are presented in the following manner:

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Aerodynamic characteristics in pitchFigure

Clean configuration:

Effect of speed-brake deflection:

At constant tail incidence and gap

Forward position of brake 5(a)

Rearward position of brake 5(b)

Effect of horizontal stabilizer incidence:

At zero brake deflection 6(a)

At constant brake deflection and gap

Forward position 6(b)

Rearward position 6(c)

Landing configuration (without ground board):

Effect of speed-brake deflection:

At constant tail incidence and brake position 7

Effect of horizontal stabilizer incidence:

At several brake deflections and gaps

Forward position 8

At constant brake deflection and two gaps

Rearward position 9

Effect of speed-brake perforations:

At constant brake deflection and gap

Forward position 10

Effect of reversing speed brake:

At constant brake deflection and gap

Rearward position 11

Landing configuration (with ground board):

Effect of speed-brake deflection:

At constant tail incidence and gap

Forward position 12(a)

Rearward position 12(b)

Effect of horizontal stabilizer incidence:

At zero brake deflection 13(a)

At constant brake deflection and gap

Rearward position 13(b)

Effect of speed-brake position:

At constant deflection and two gaps and tail incidences . . . 14

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Lateral characteristics:

Stability parameters:

Plain wing (no notches or fences) 15

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., December 4, 1953.

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by RSV

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Approved:

Thomas A. Harris

Thomas A. Harris
Chief of Stability Research Division

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1. Lockwood, Vernard E., and Solomon, Martin: Stability and Control Characteristics at Low Speed of a 1/10-Scale Model of MX-1554A Design. NACA RM SL53AO5, U. S. Air Force, 1953.
2. Lockwood, Vernard E., and Solomon, Martin: Stability and Control Characteristics at Low Speed of a Modified 1/10-Scale Model of the MX-1554A Design. NACA RM SL53K25, U. S. Air Force, 1953.
3. Gillis, Clarence L., Polhamus, Edward C., and Gray, Joseph L., Jr.: Charts for Determining Jet-Boundary Corrections for Complete Models in 7- by 10-Foot Closed Rectangular Wind Tunnels. NACA WRL-123, 1945. (Formerly NACA ARR L5G31.)

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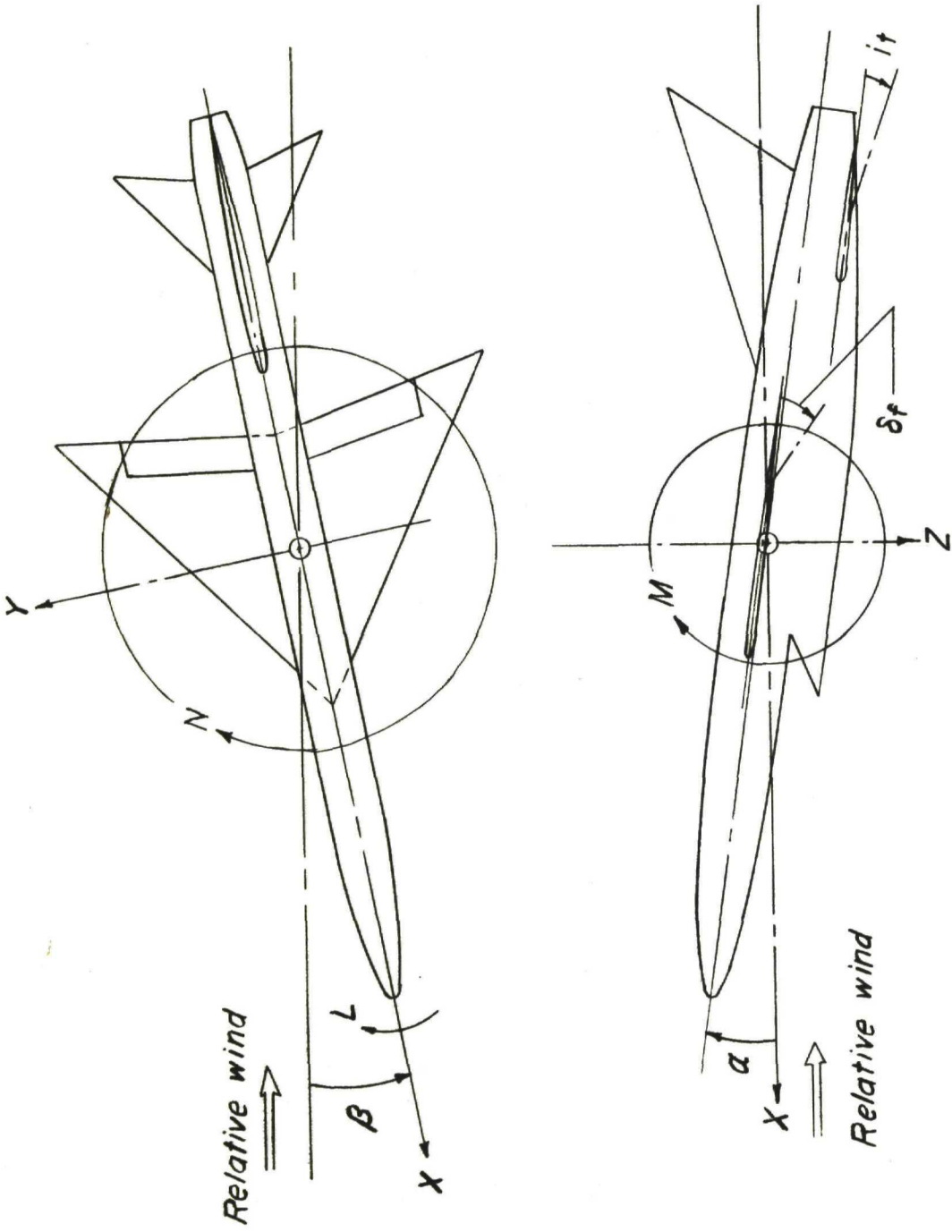


Figure 1.- System of axes and control-surface deflections. Positive directions of forces, moments, and angles are indicated by arrows.

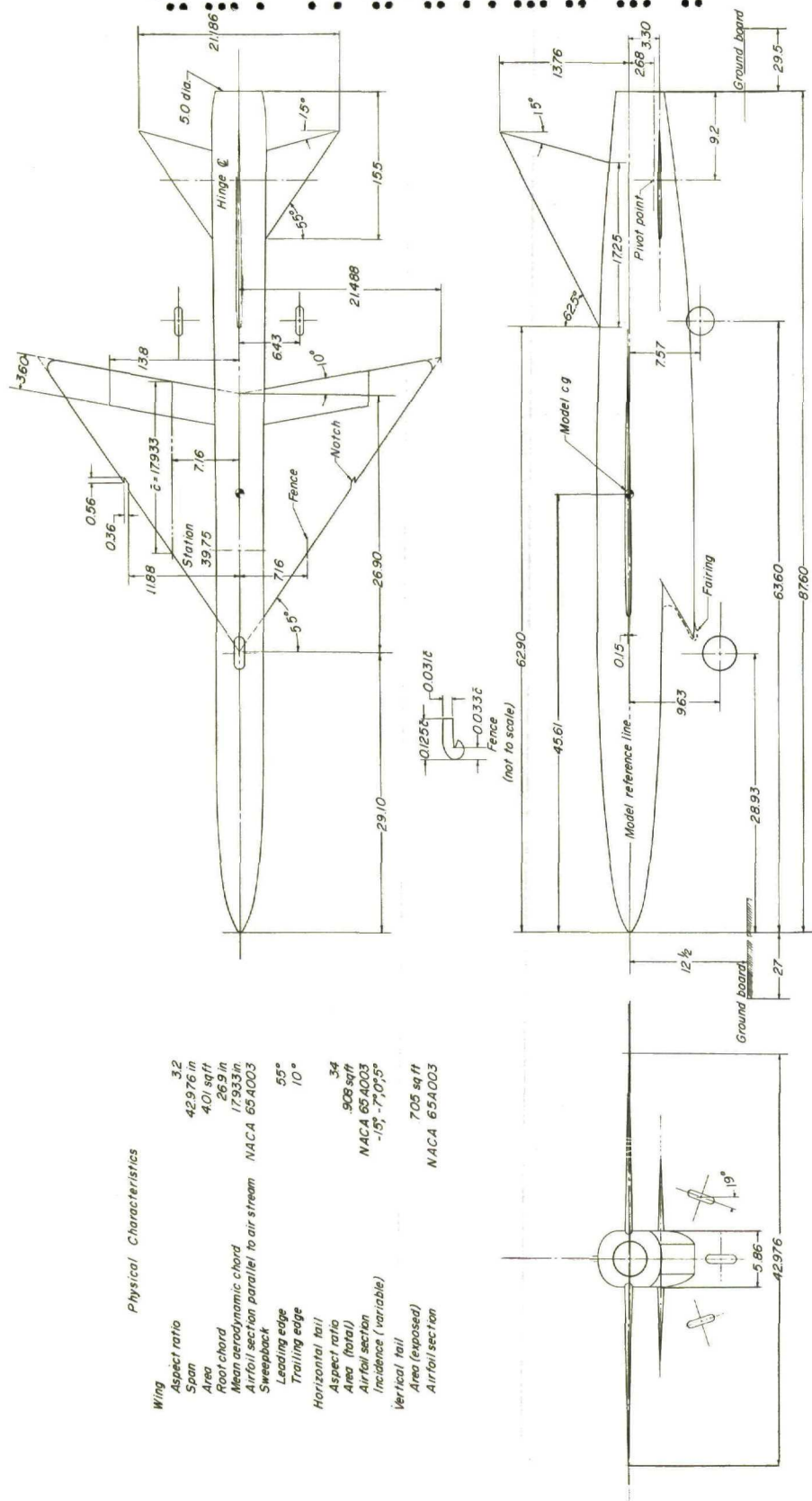


Figure 2.- Three-view drawing of the MX-1554A model tested. All dimensions in inches unless otherwise noted.

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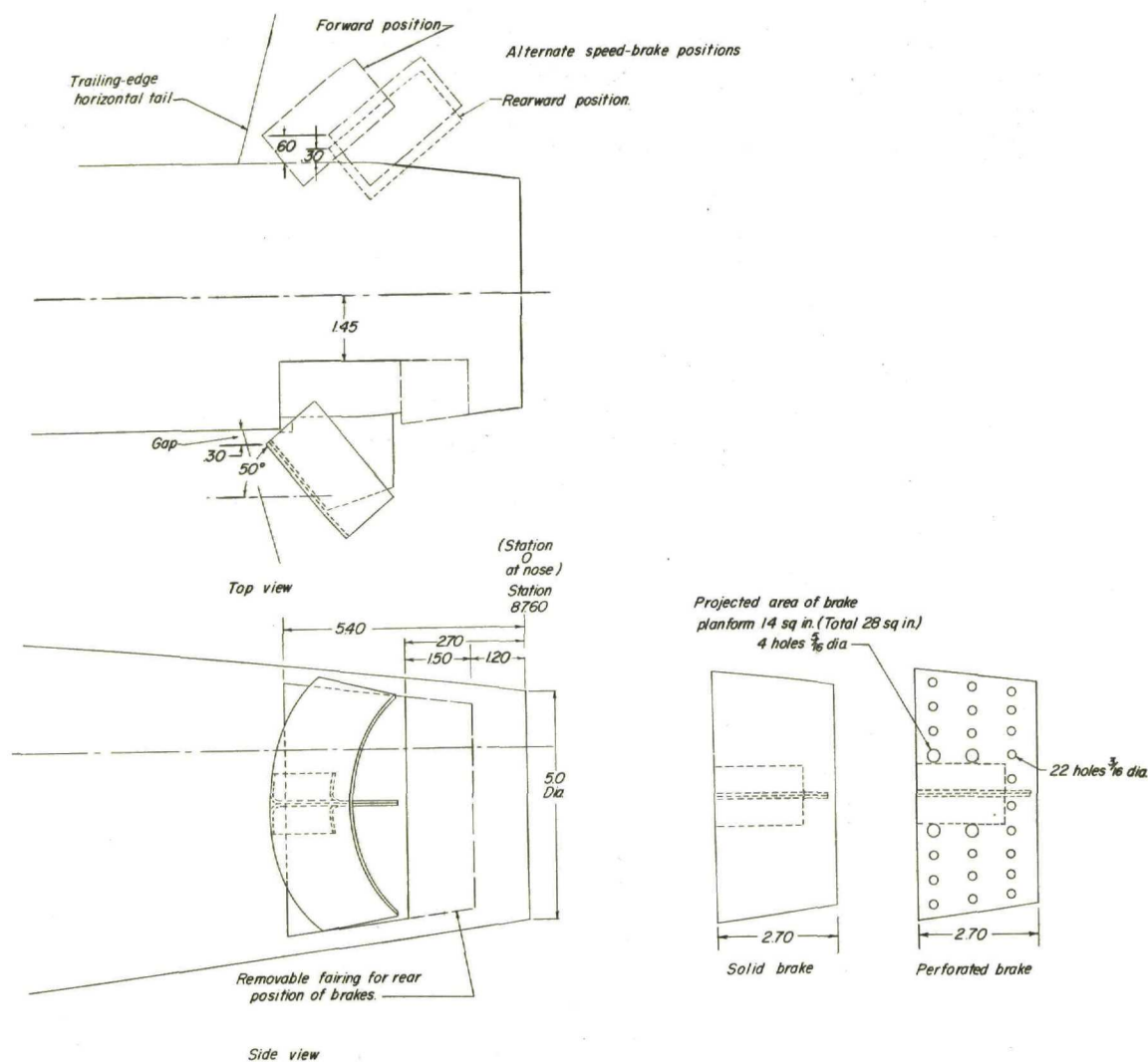
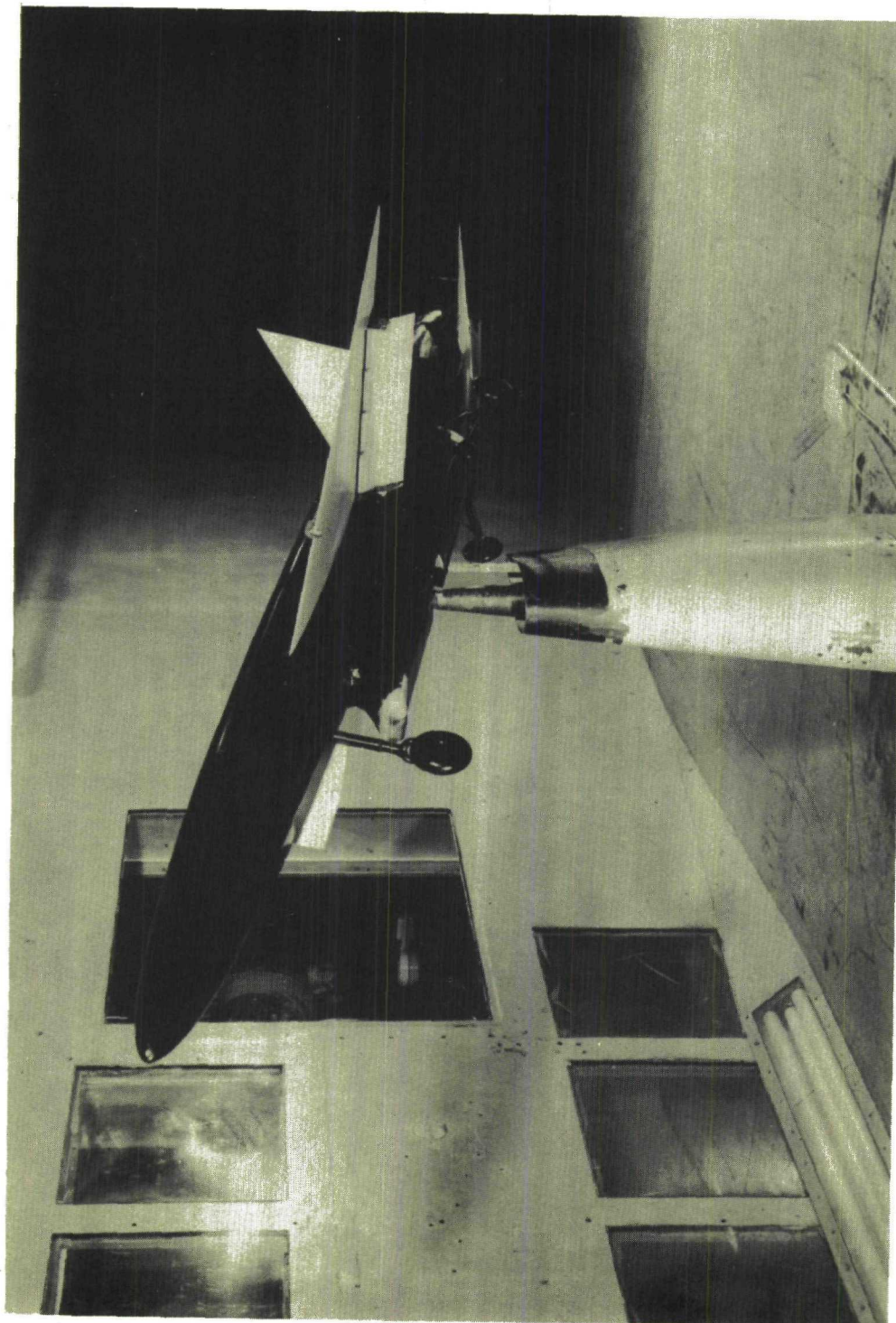


Figure 3.- Drawings of the speed brakes tested. All dimensions in inches unless otherwise noted.

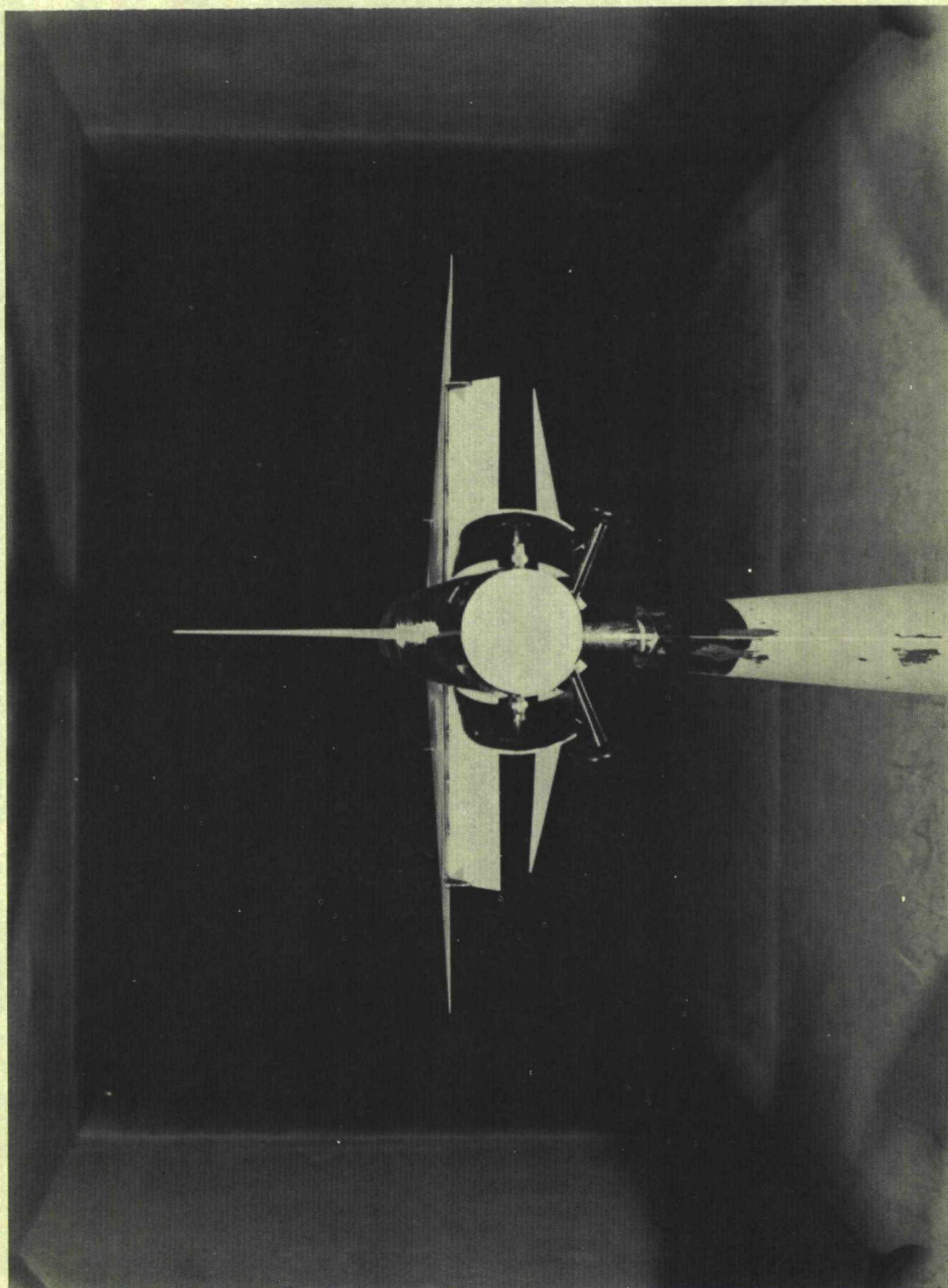
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Figure 4.- The MX-1554A model mounted on the single support strut in the Langley 300 MPH 7- by 10-foot tunnel. Landing configuration; $\delta_f = 50^\circ$; $\delta_{SB} = 40^\circ$; rearward position; gap, 0.30 inch.

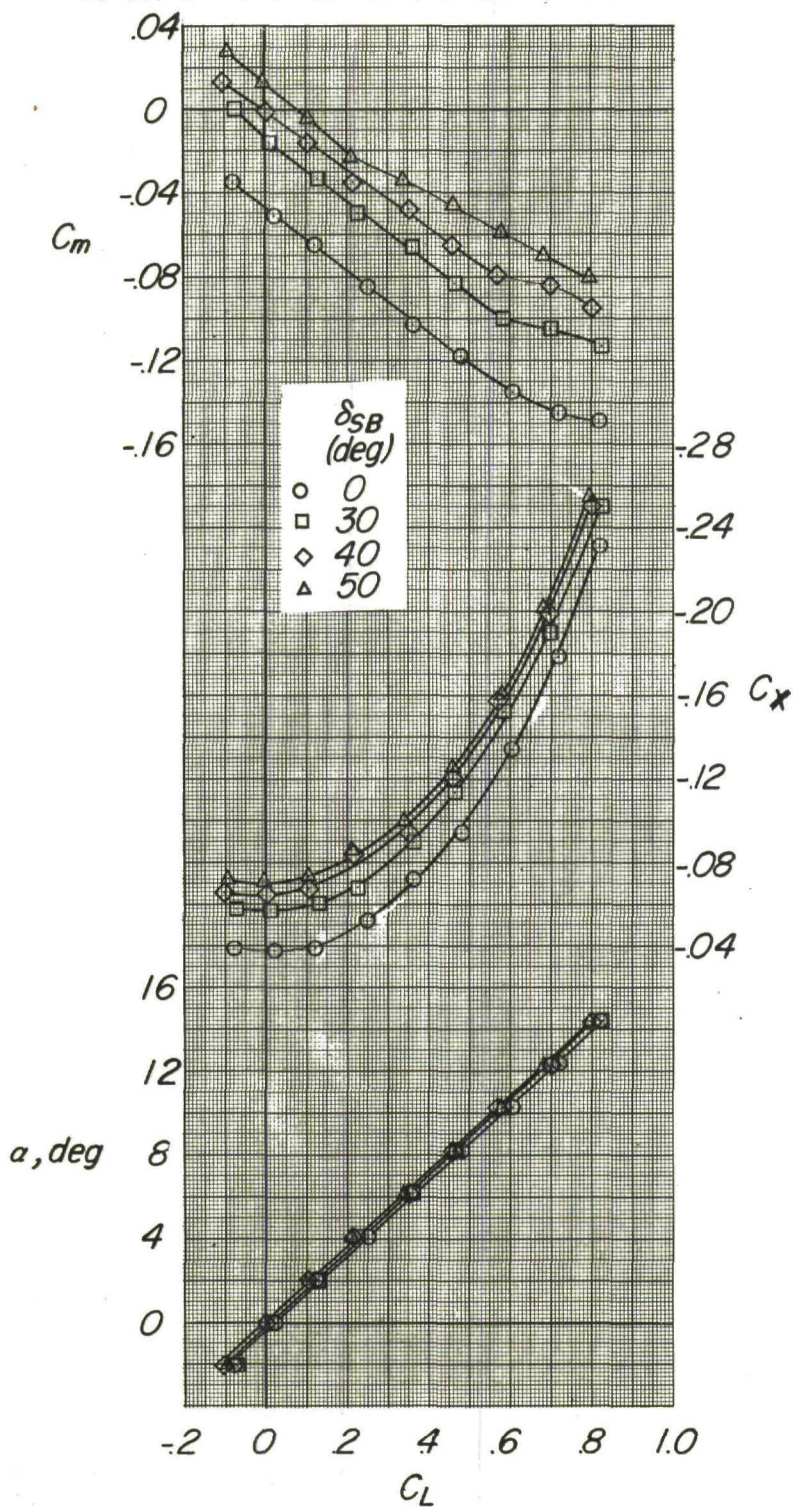
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Figure 4.- Concluded.

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(a) Forward position of brake.

Figure 5.- The effect of speed-brake deflection on the aerodynamic characteristics in pitch. Clean configuration; $\delta_F = 0^\circ$; $i_t = 5^\circ$; gap, 0.30 inch.

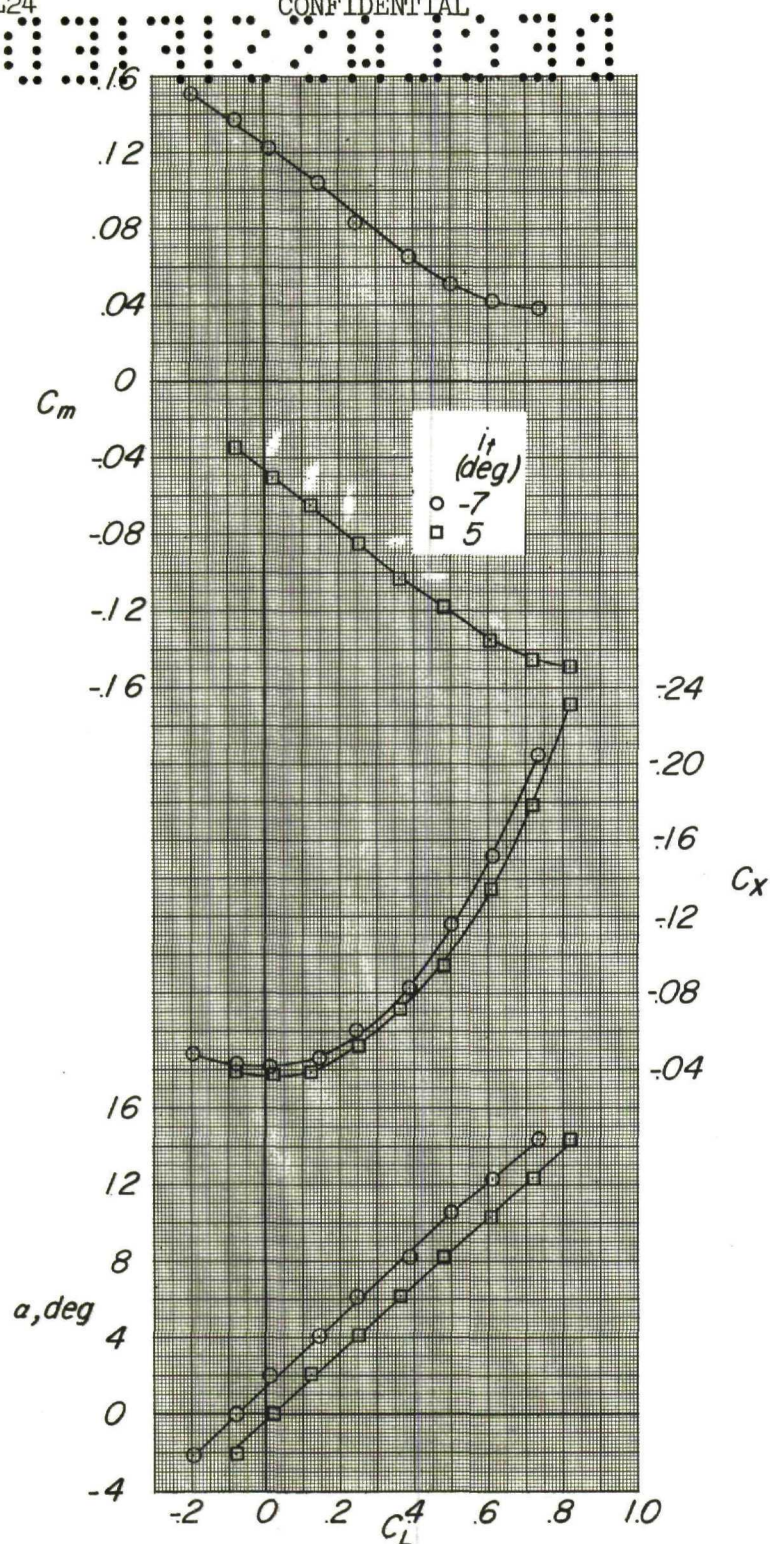
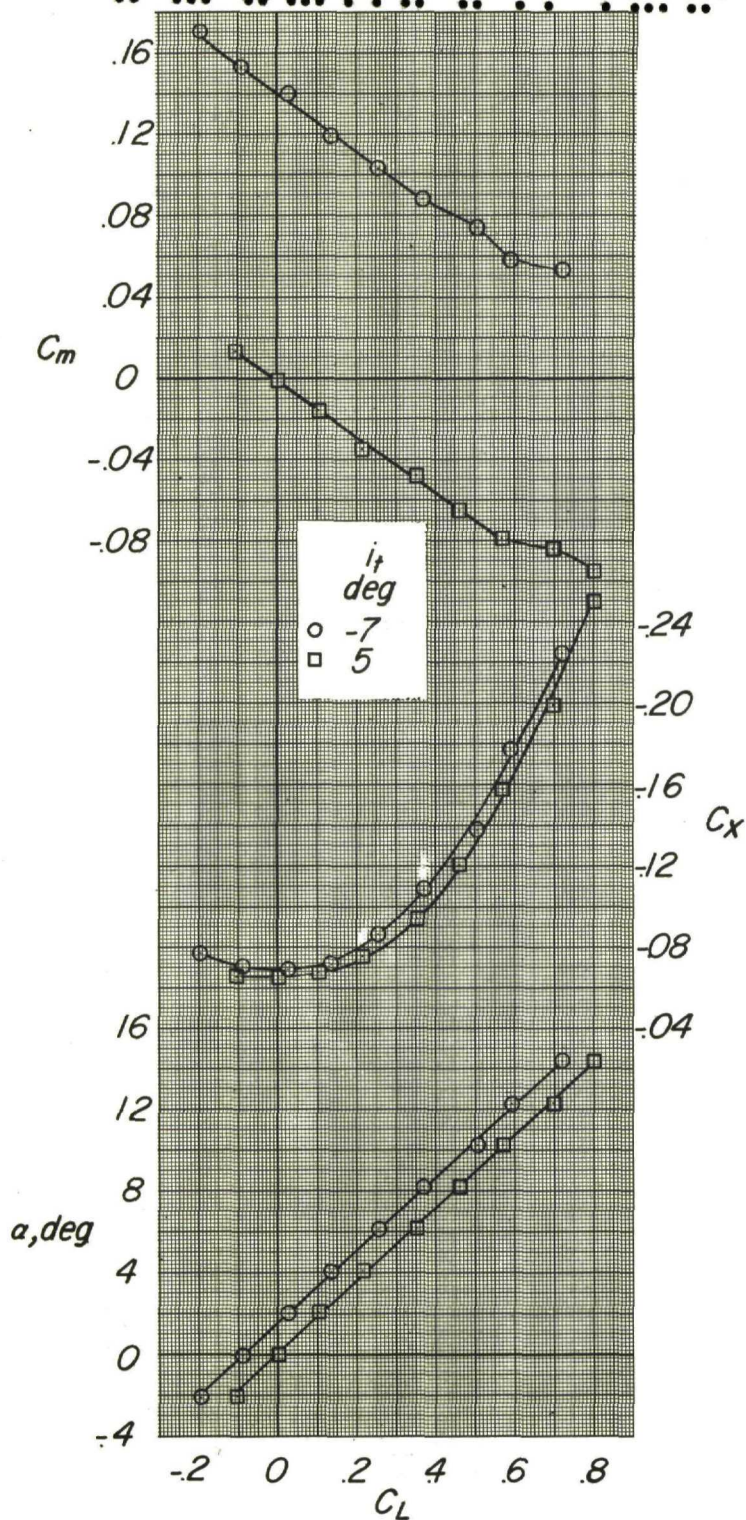
(a) $\delta_{SB} = 0^\circ$.

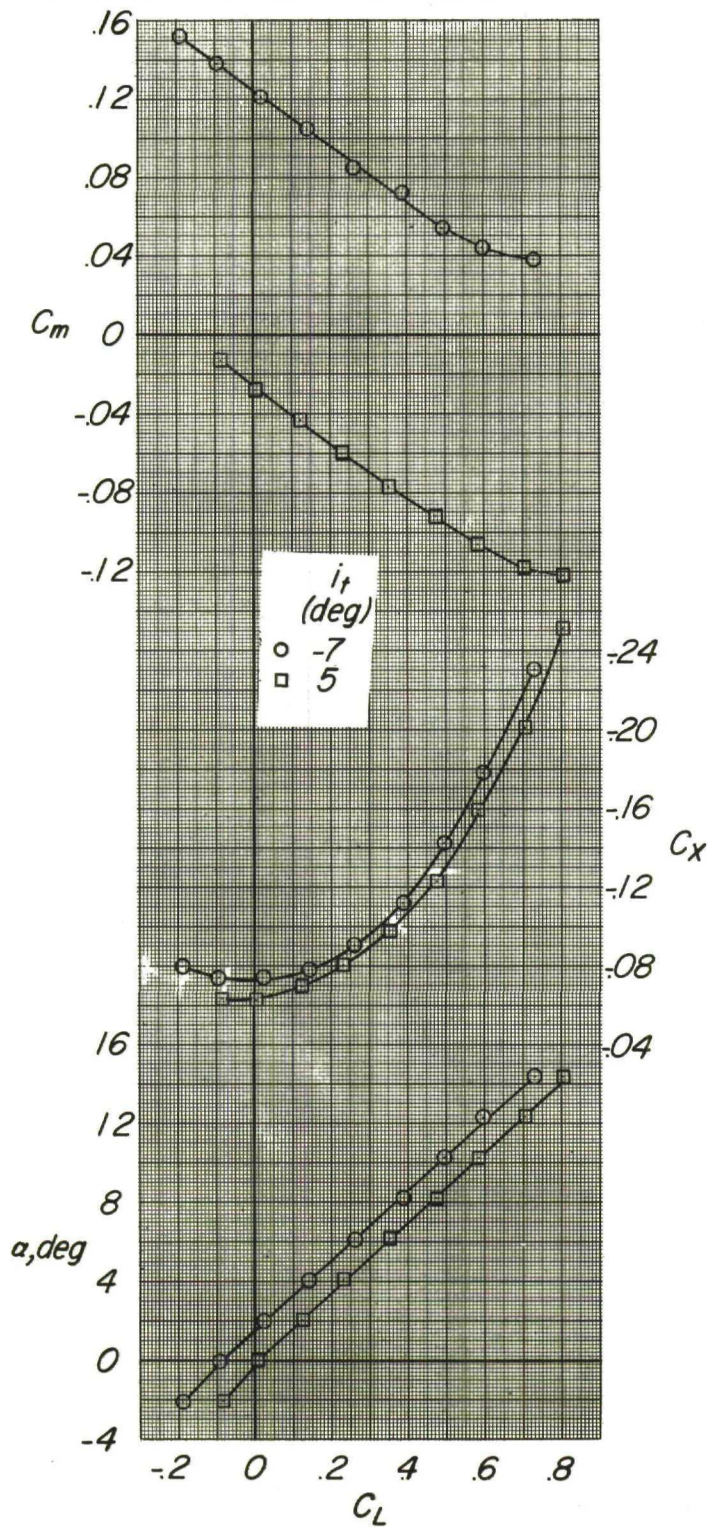
Figure 6.- The effect of horizontal stabilizer incidence on the aerodynamic characteristics in pitch. Clean configuration; $\delta_f = 0^\circ$.

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(b) $\delta_{SB} = 40^\circ$; forward position; gap, 0.30 inch.

Figure 6.- Continued.



(c) $\delta_{SB} = 40^\circ$; rearward position; gap, 0.30 inch.

Figure 6.- Concluded.

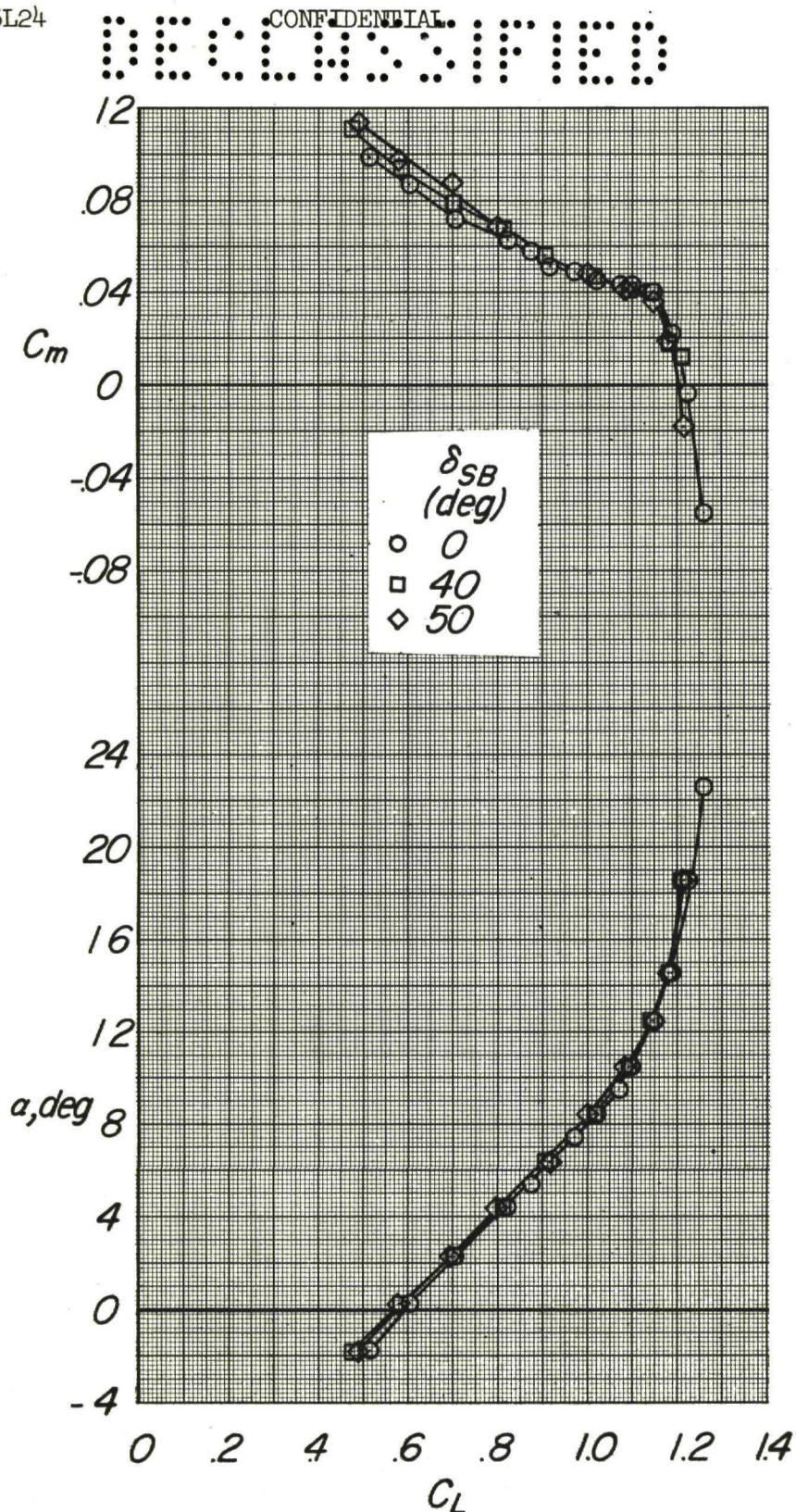


Figure 7.- The effect of speed-brake deflection on the aerodynamic characteristics in pitch. Landing configuration; $\delta_f = 50^\circ$; $i_t = -15^\circ$; brake position rearward; gap, 0.30 inch.

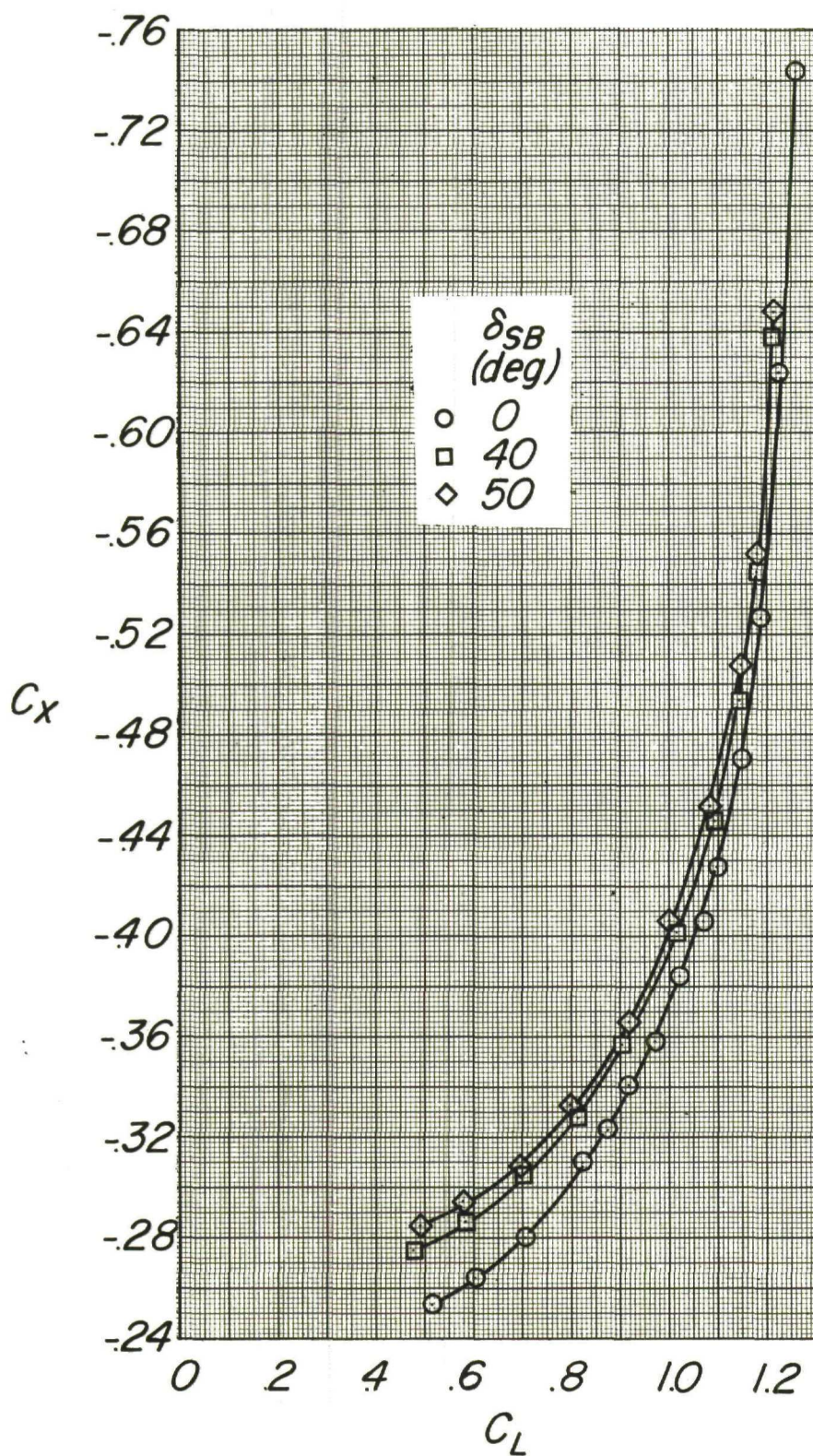


Figure 7.- Concluded.

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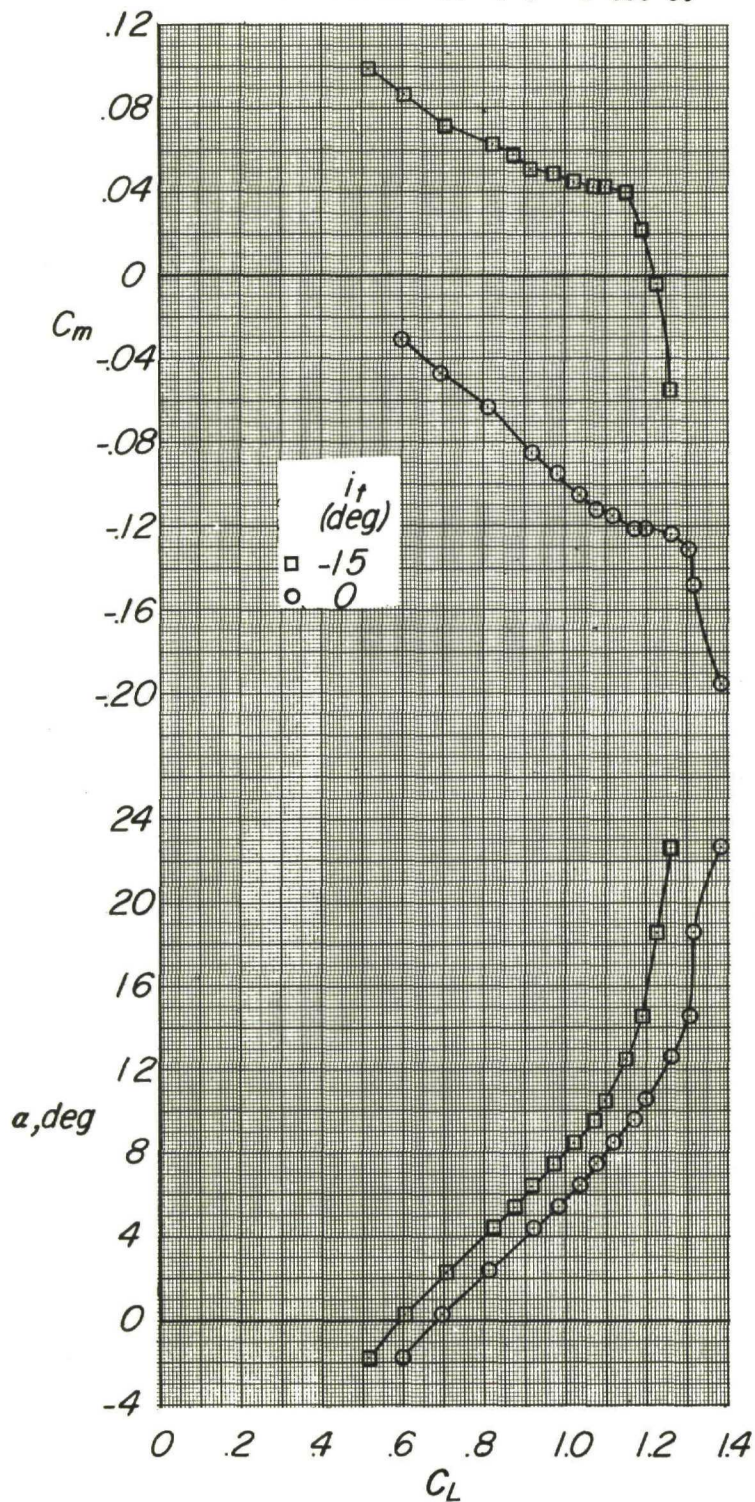
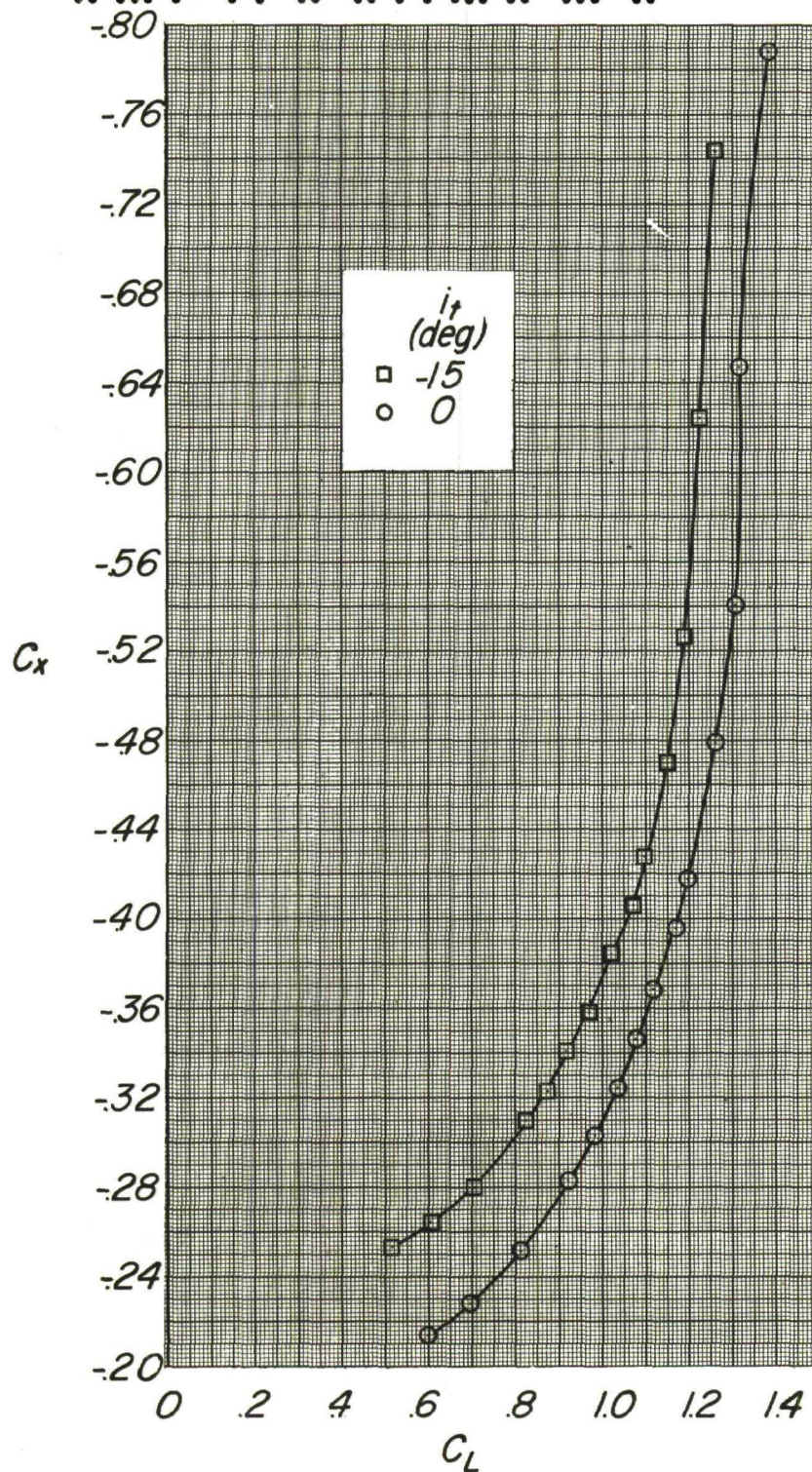
(a) $\delta_{SB} = 0^\circ$.

Figure 8.- The effect of horizontal stabilizer incidence on the aerodynamic characteristics in pitch. Landing configuration; $\delta_f = 50^\circ$.

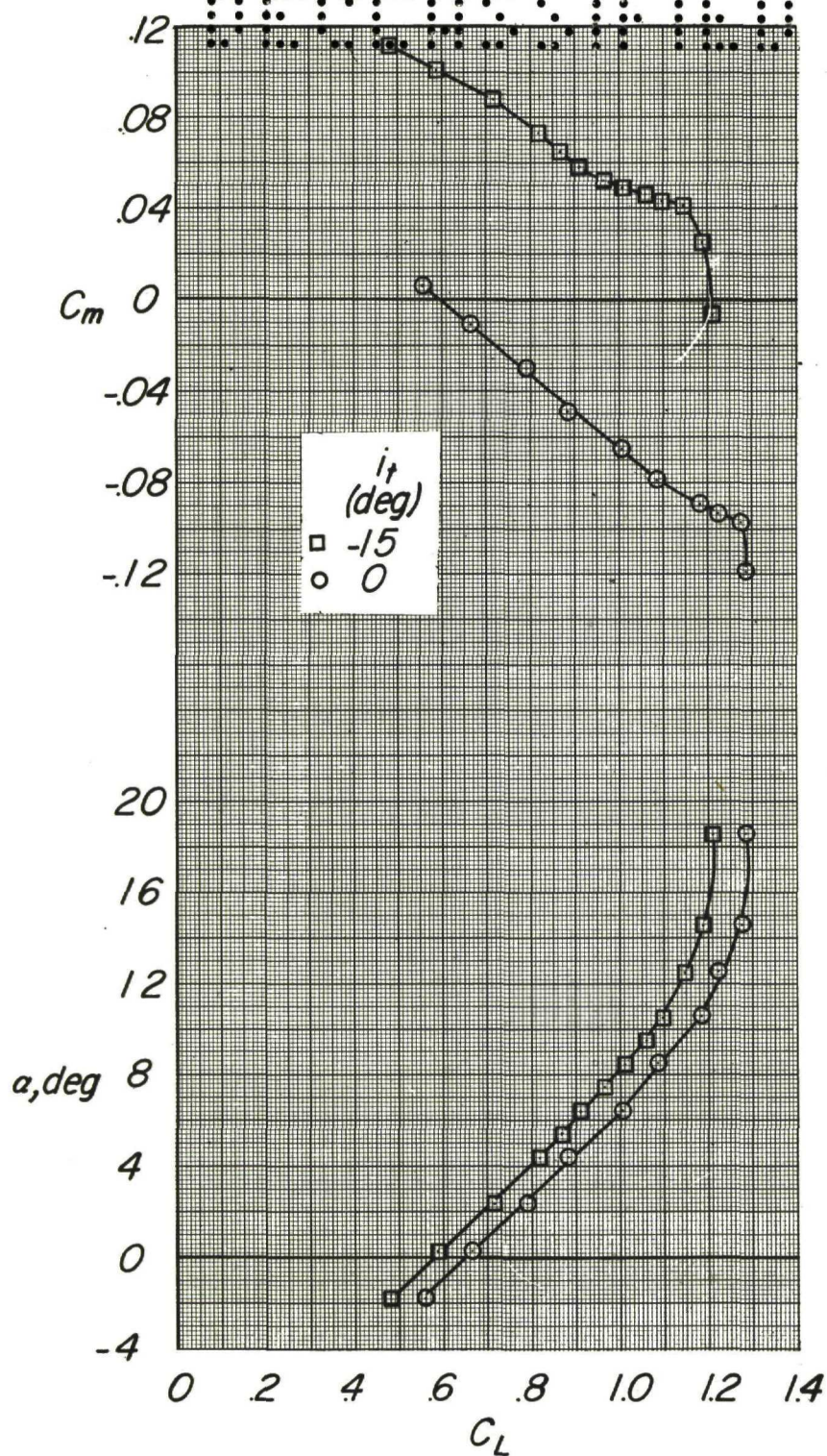
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(a) Concluded.

Figure 8.- Continued.

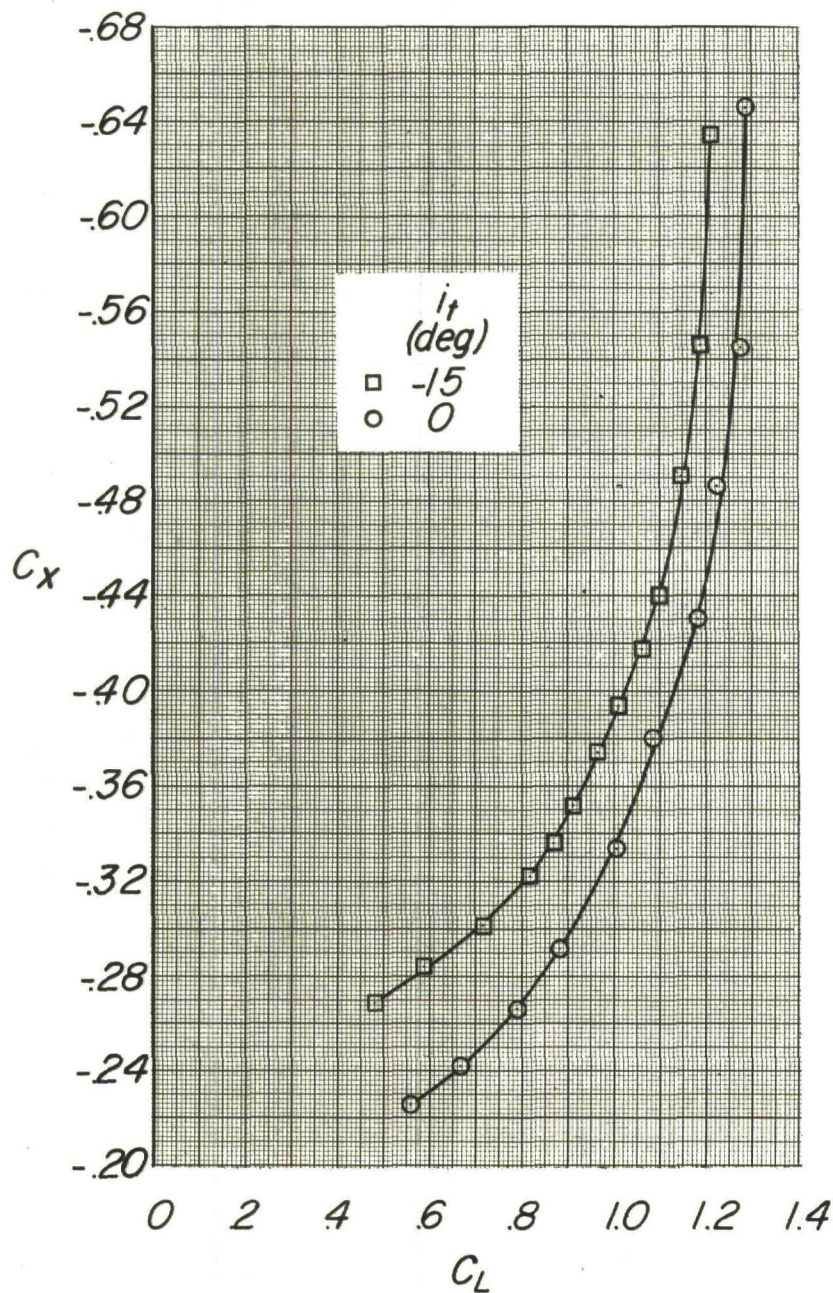
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(b) $\delta_{SB} = 30^\circ$; forward position; gap, 0.30 inch.

Figure 8.- Continued.

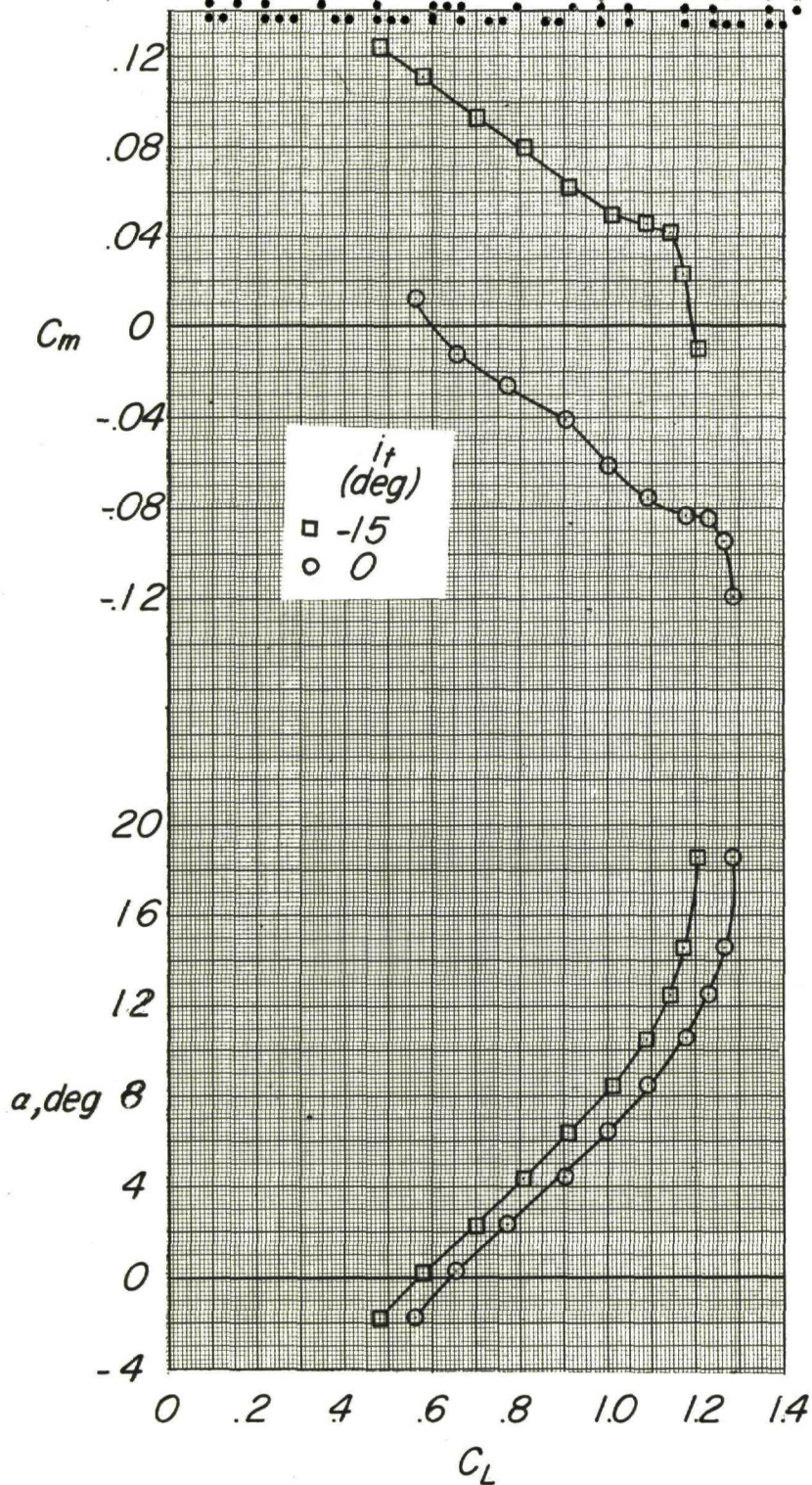
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(b) Concluded.

Figure 8.- Continued.

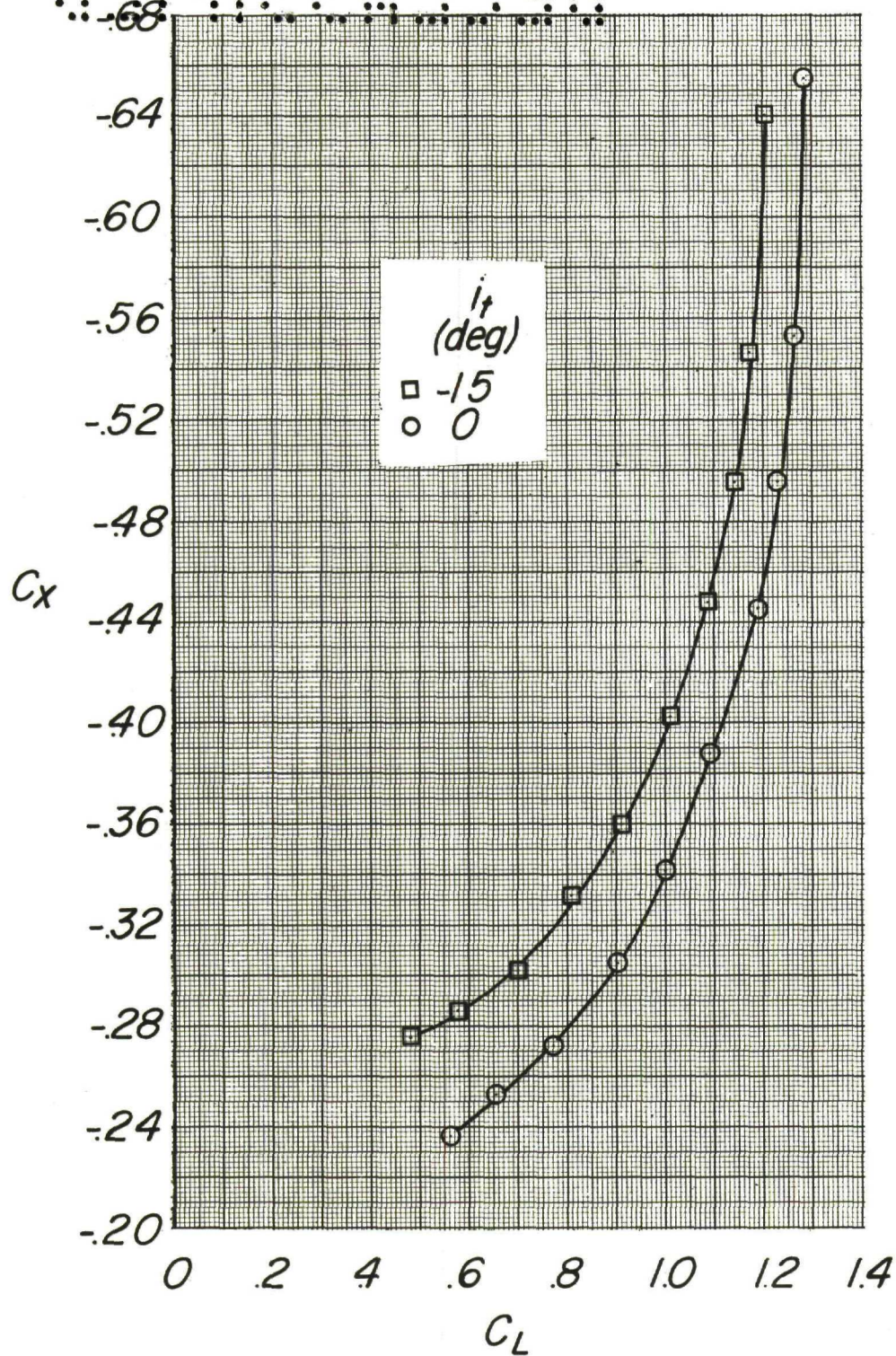
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(c) $\delta_{SB} = 40^\circ$; forward position; gap, 0.30 inch.

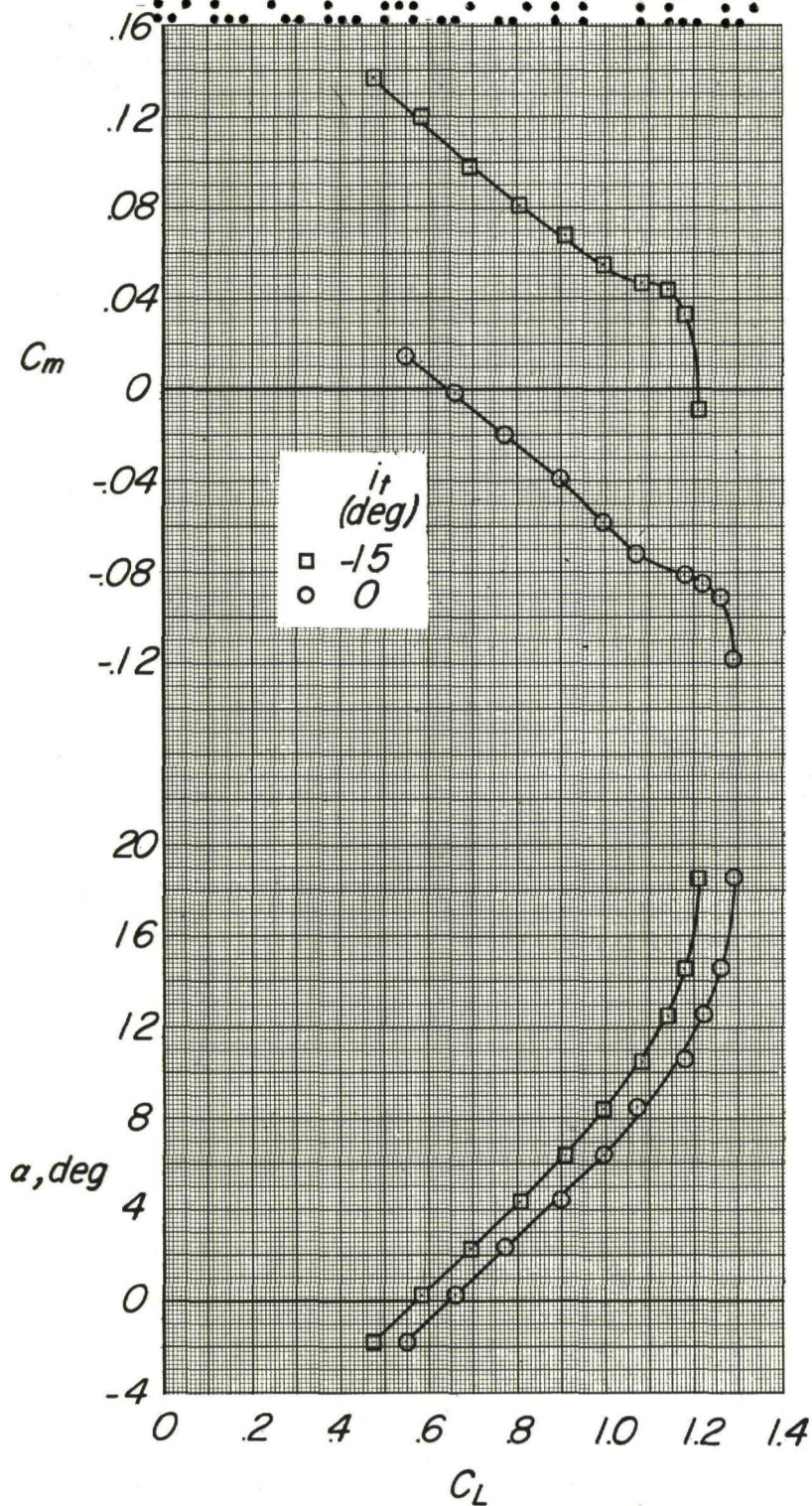
Figure 8.- Continued.

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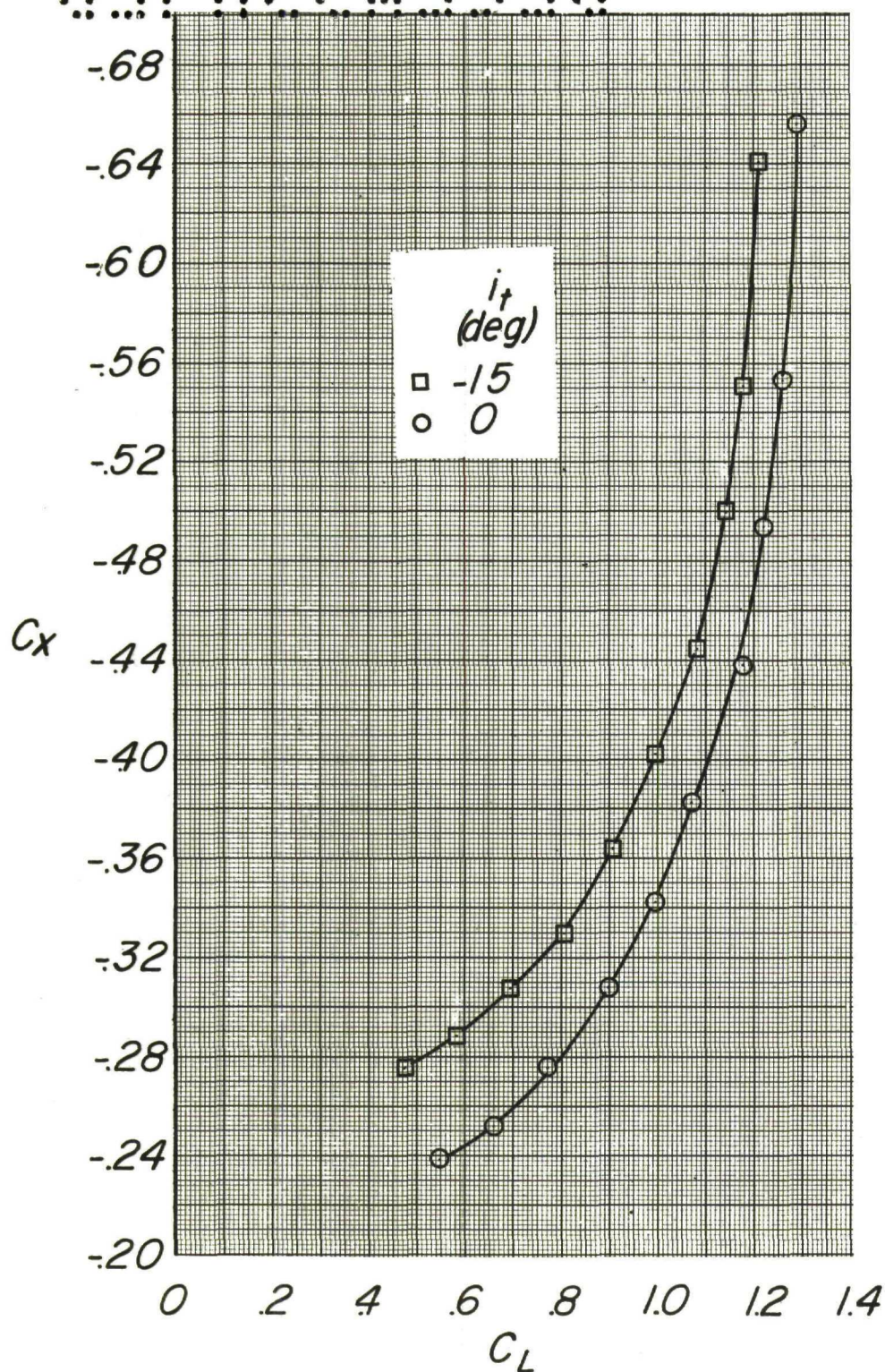
(c) Concluded.

Figure 8.- Continued.



(d) $\delta_{SB} = 40^\circ$; forward position; gap, 0.60 inch.

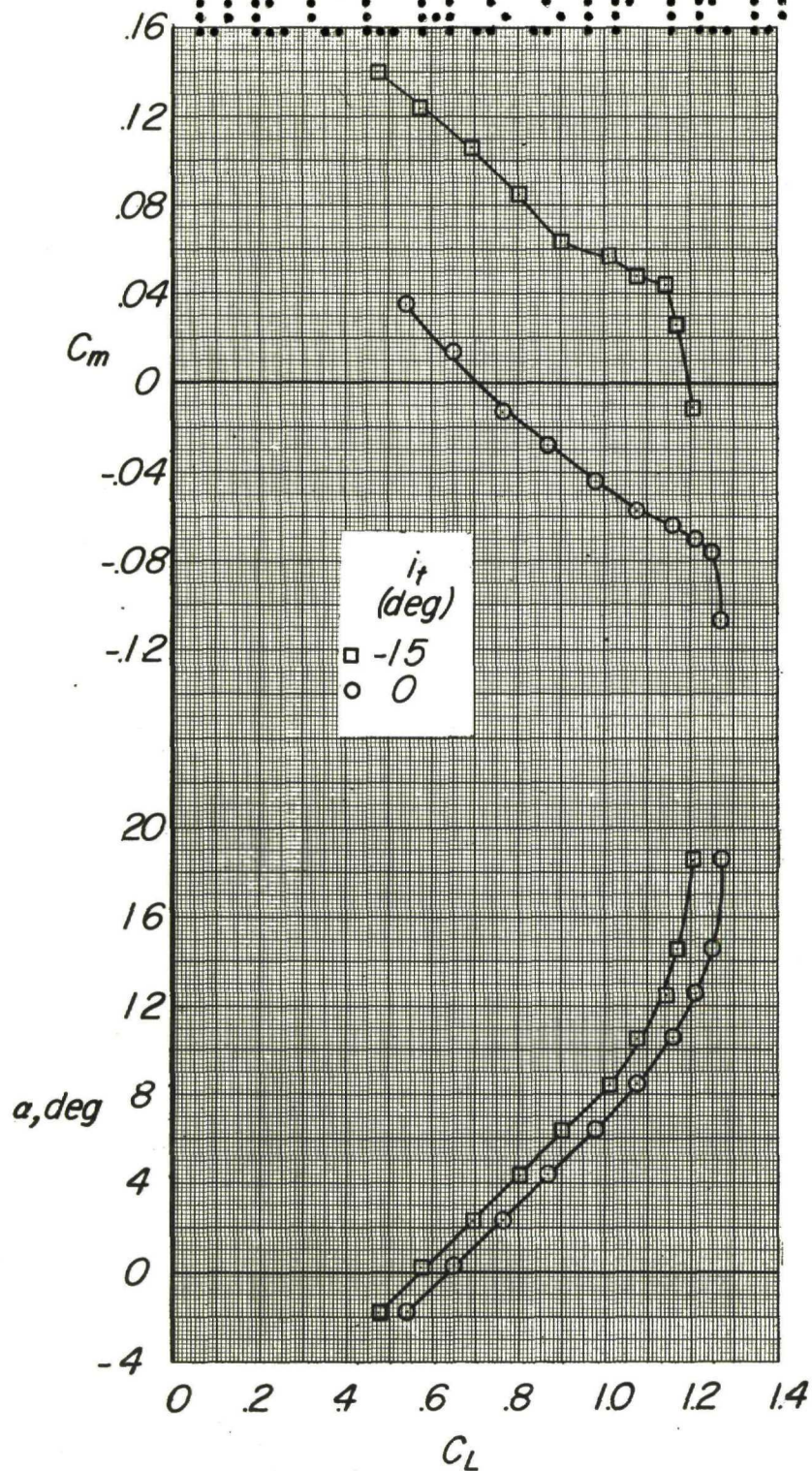
Figure 8.- Continued.



(d) Concluded.

Figure 8.- Continued.

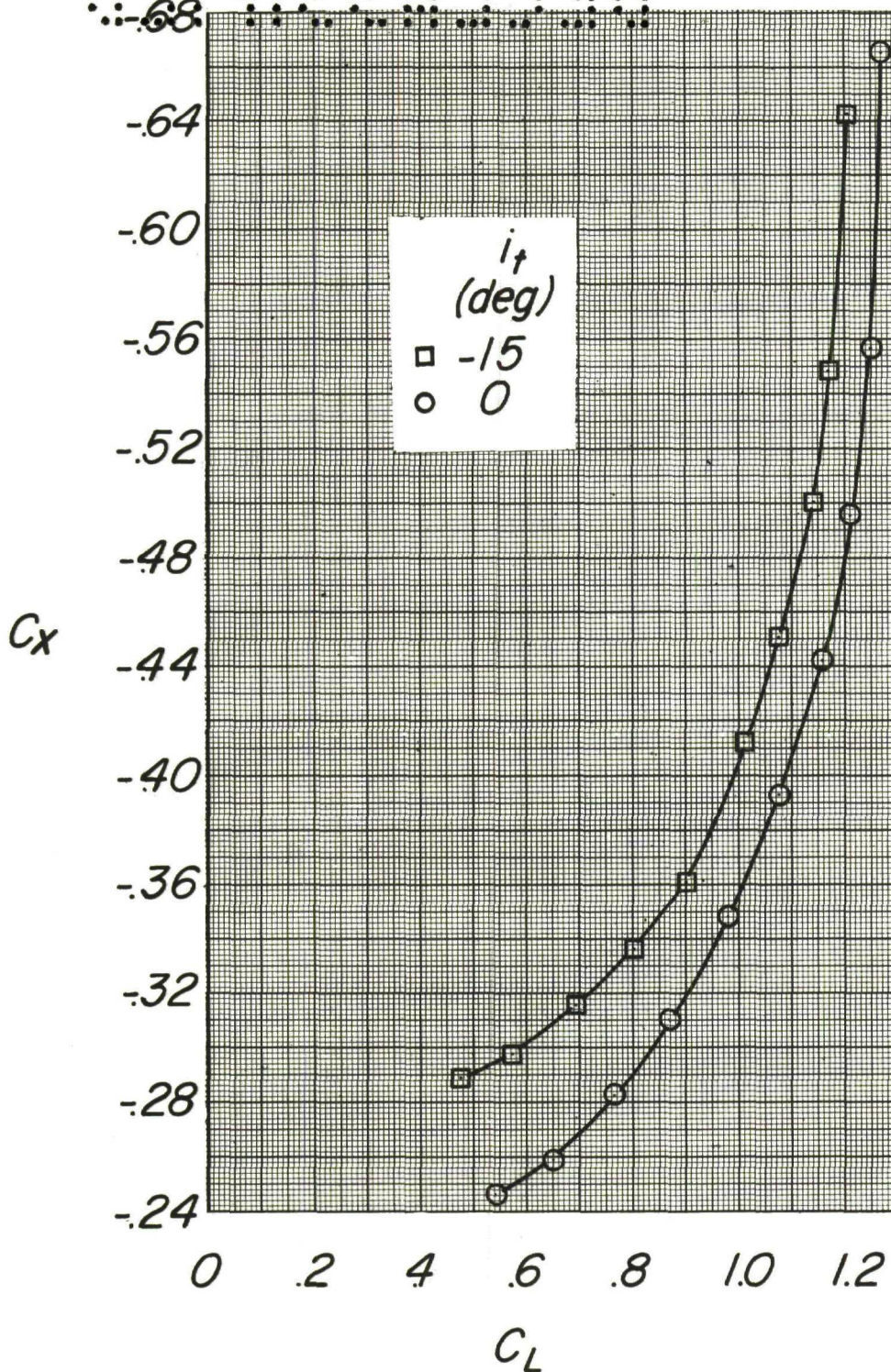
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(e) $\delta_{SB} = 50^\circ$; forward position; gap, 0.30 inch.

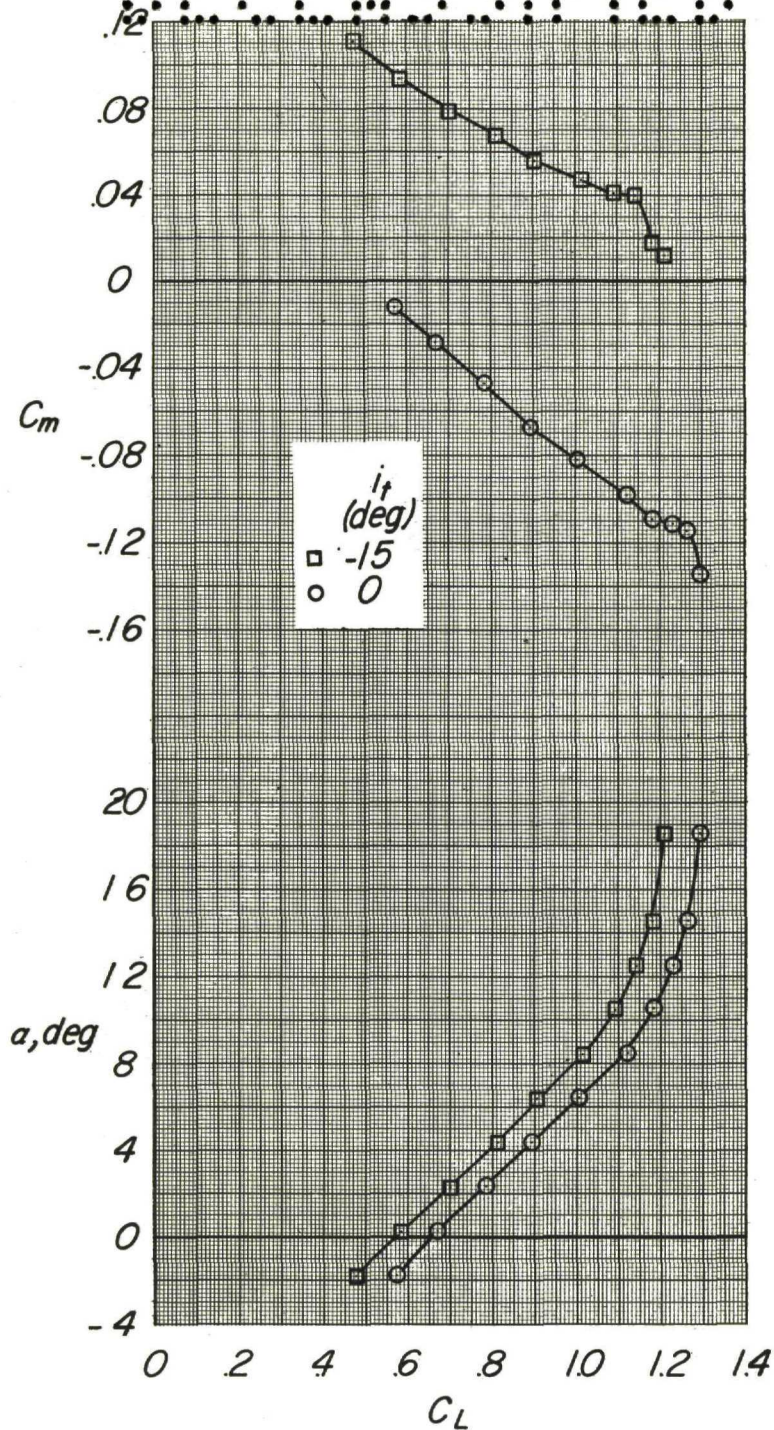
Figure 8.- Continued.

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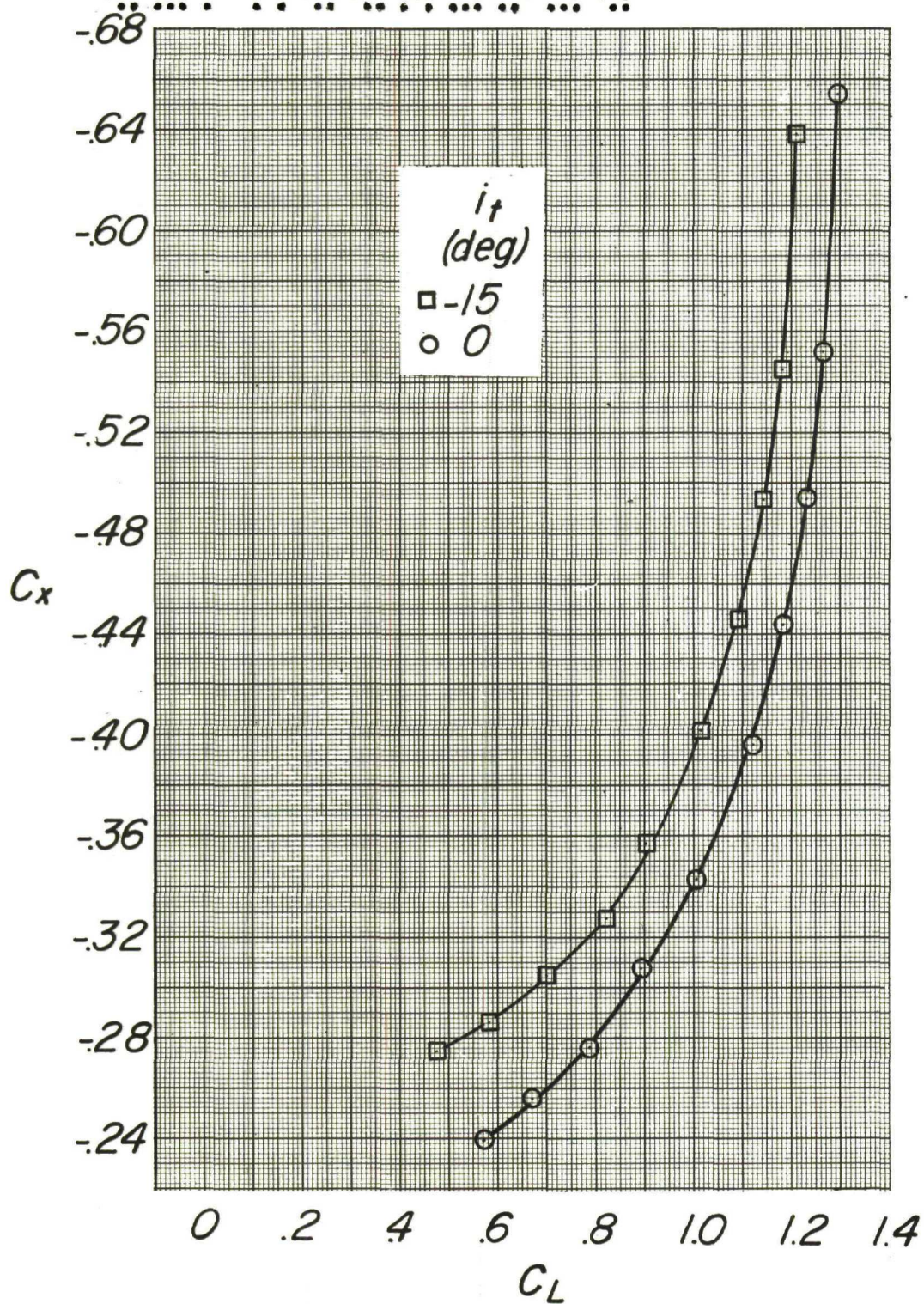
(e) Concluded.

Figure 8.- Concluded.



(a) Gap, 0.30 inch.

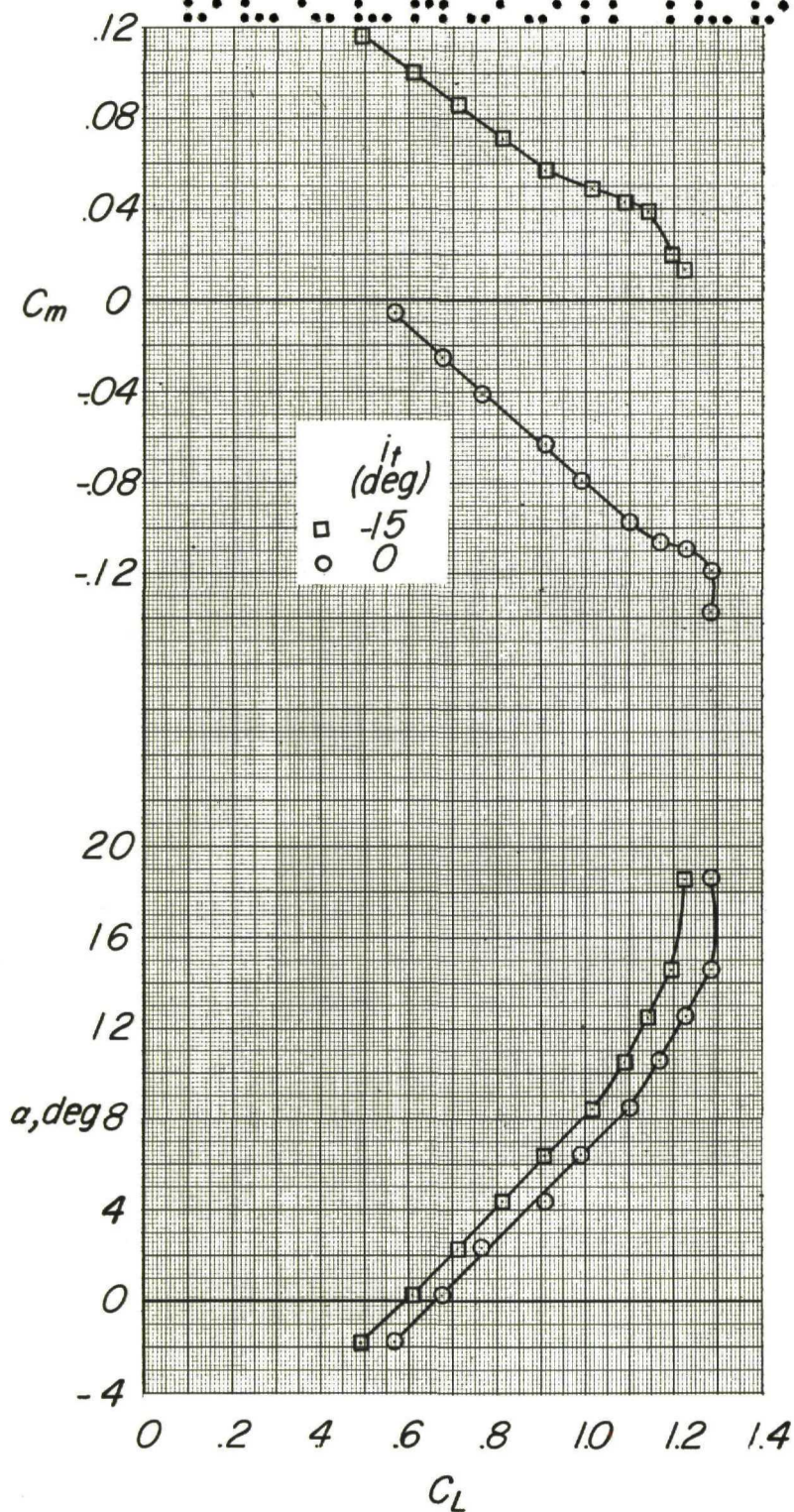
Figure 9.- The effect of horizontal stabilizer incidence on the aerodynamic characteristics in pitch. Landing configuration; $\delta_f = 50^\circ$; $\delta_{SB} = 40^\circ$; brake position rearward.



(a) Concluded.

Figure 9.- Continued.

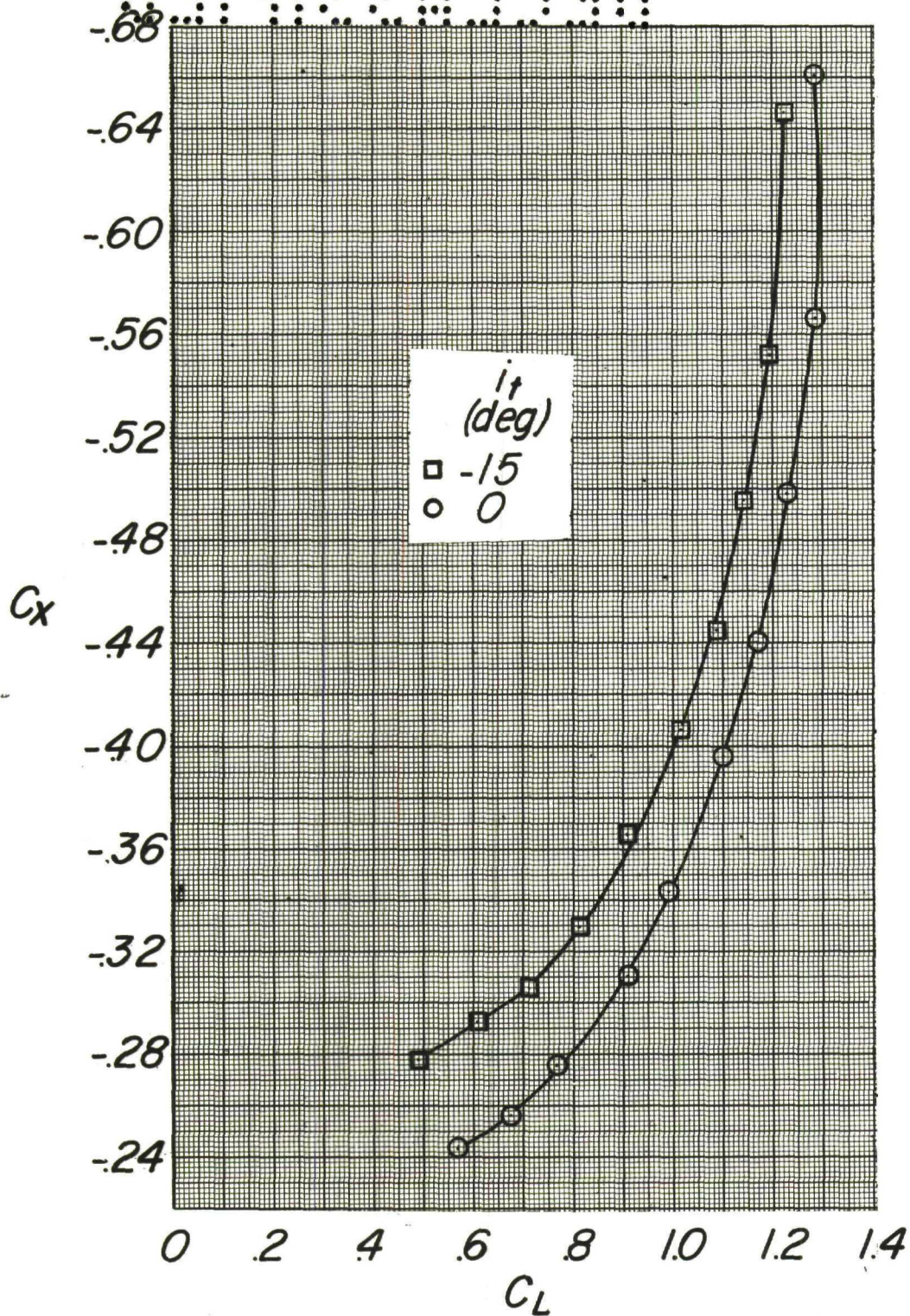
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(b) Gap, 0.60 inch.

Figure 9.- Continued.

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(b) Concluded.

Figure 9.- Concluded.

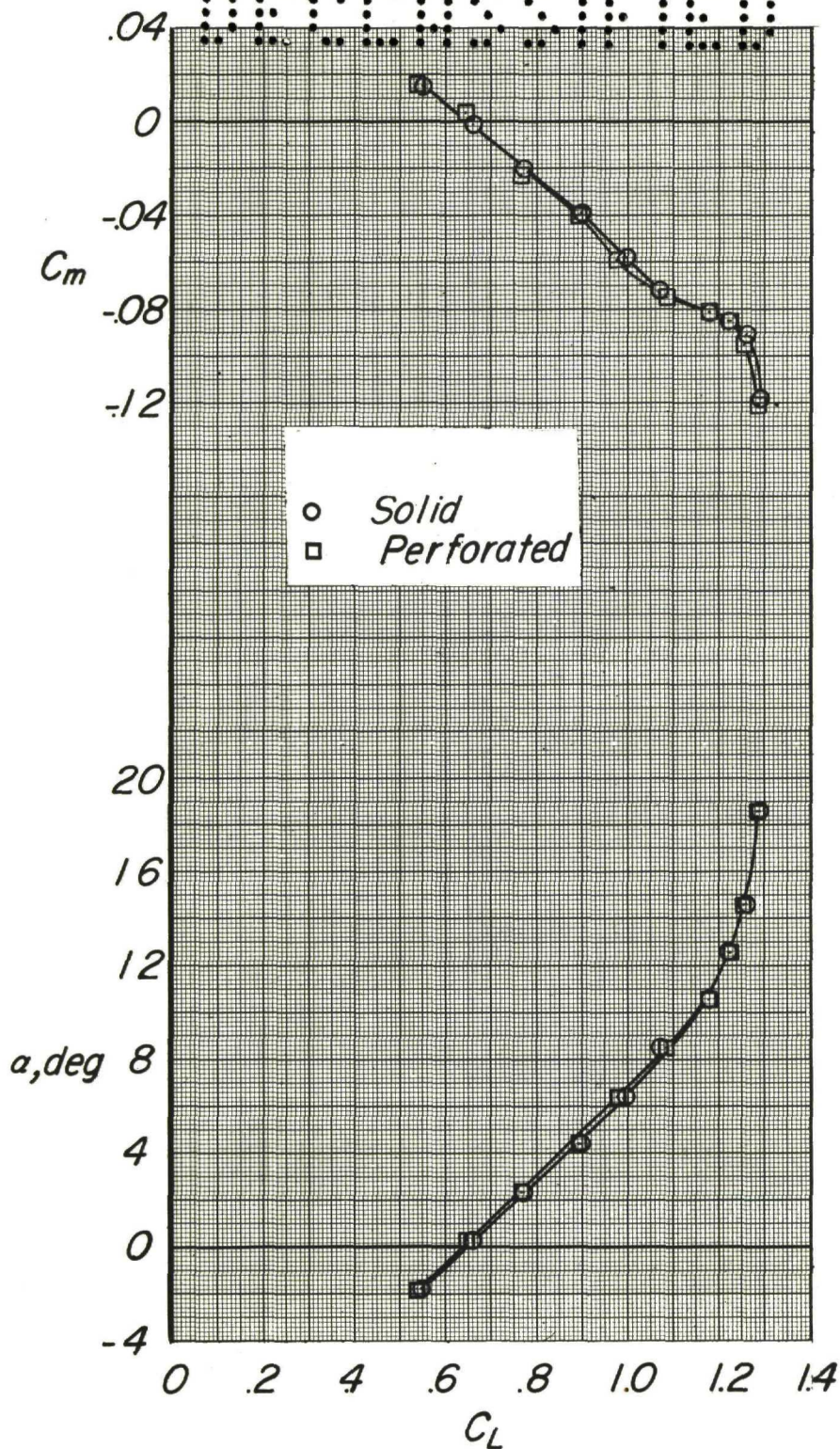


Figure 10.- The effect of speed-brake perforations on the aerodynamic characteristics in pitch. Landing configuration; $\delta_f = 50^\circ$; $i_t = 0^\circ$; $\delta_{SB} = 40^\circ$; brake position forward; gap, 0.60 inch.

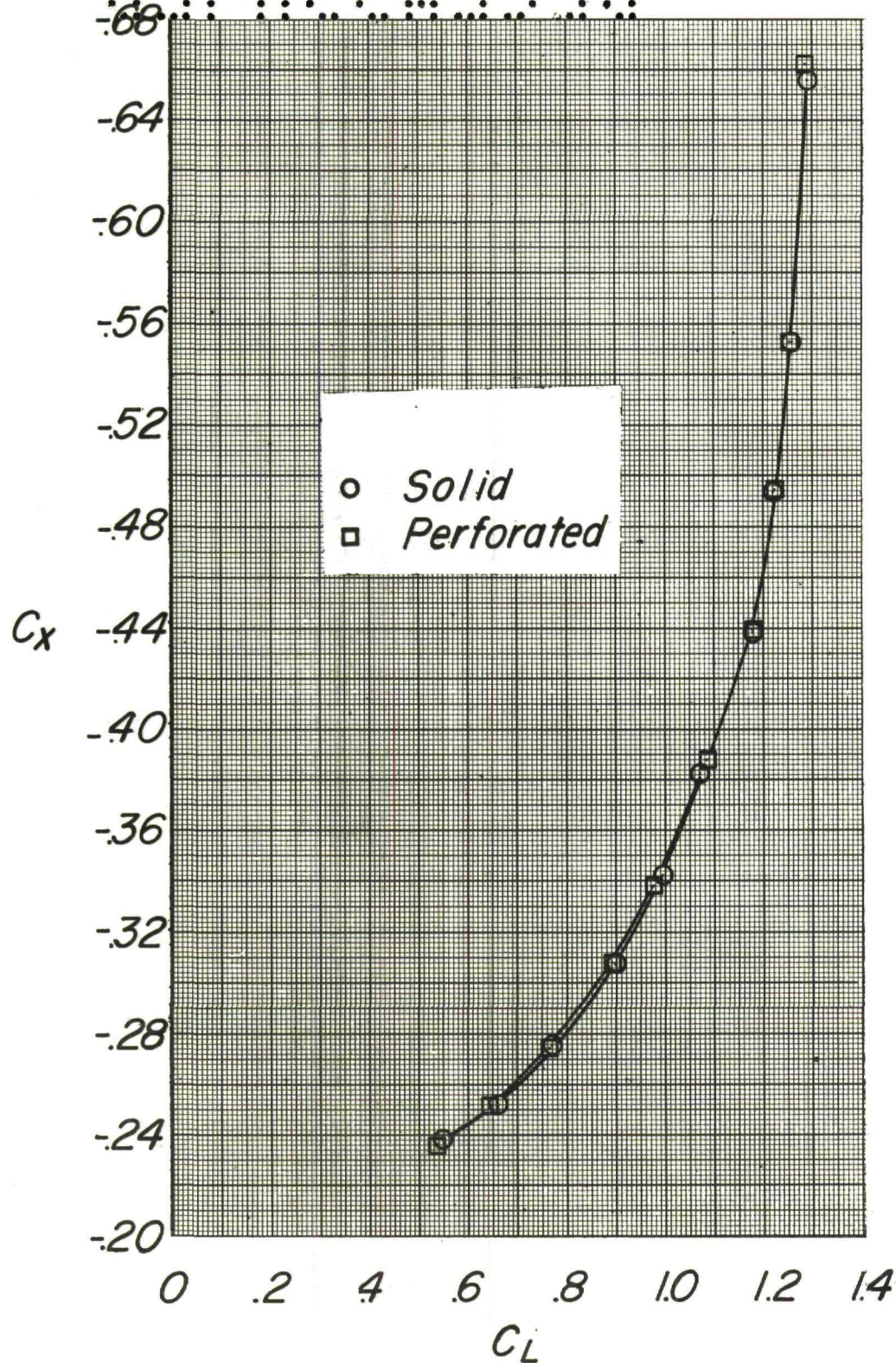


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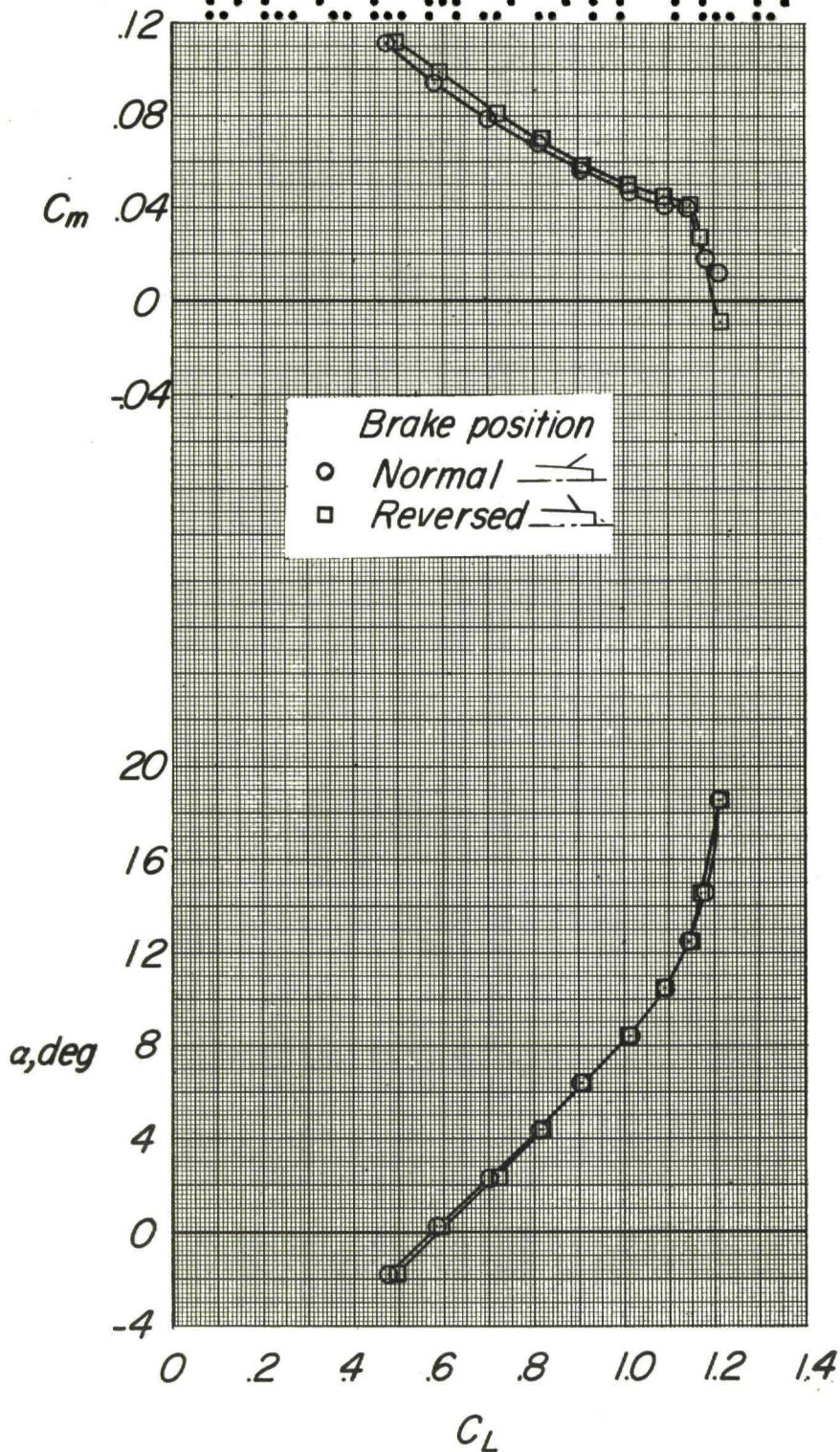


Figure 11.- The effect of reversing the brake on the aerodynamic characteristics in pitch. Landing configuration; $\delta_f = 50^\circ$; $i_t = -15^\circ$; $\delta_{SB} = 40^\circ$; brake position rearward; gap, 0.30 inch.

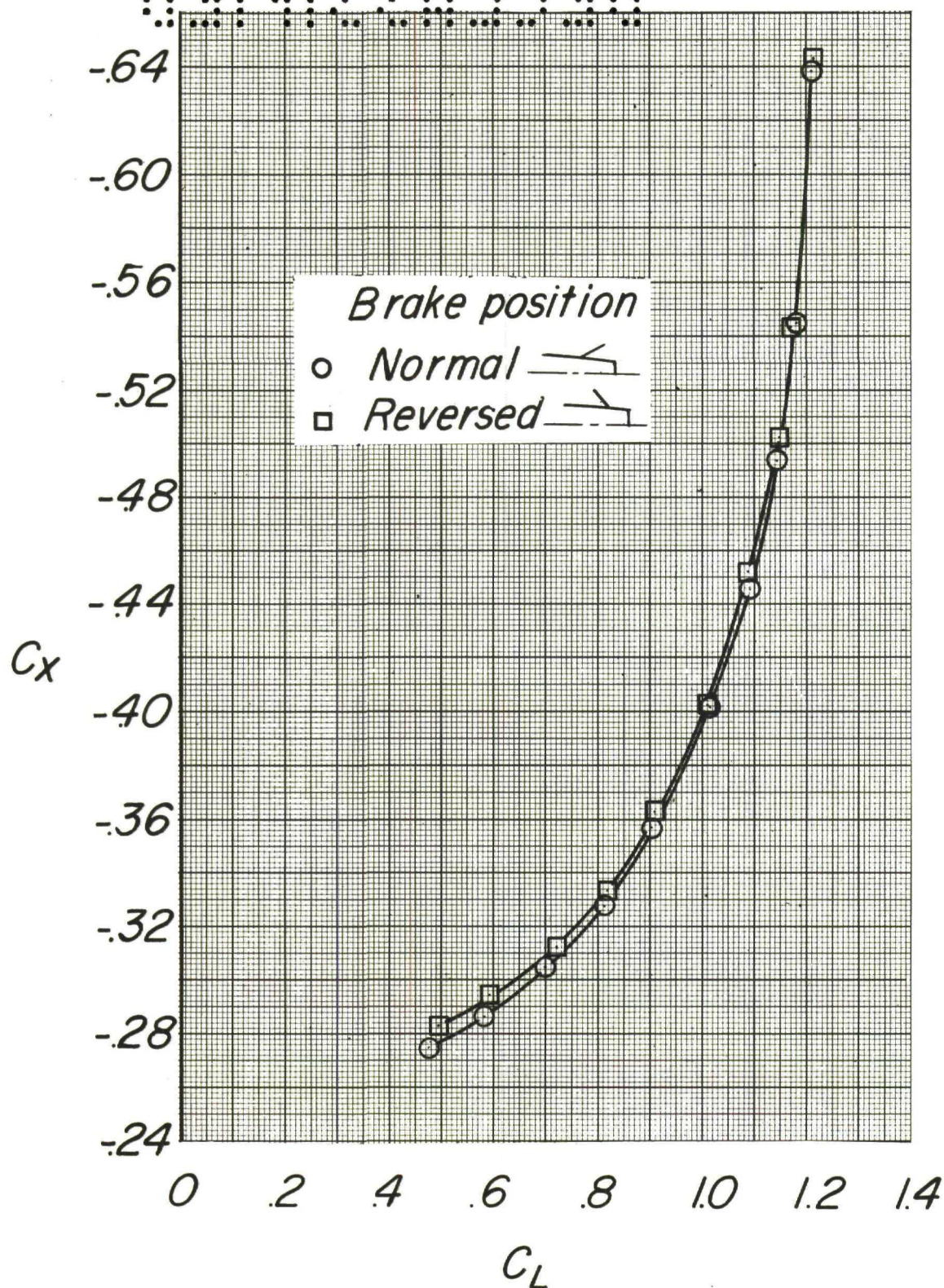
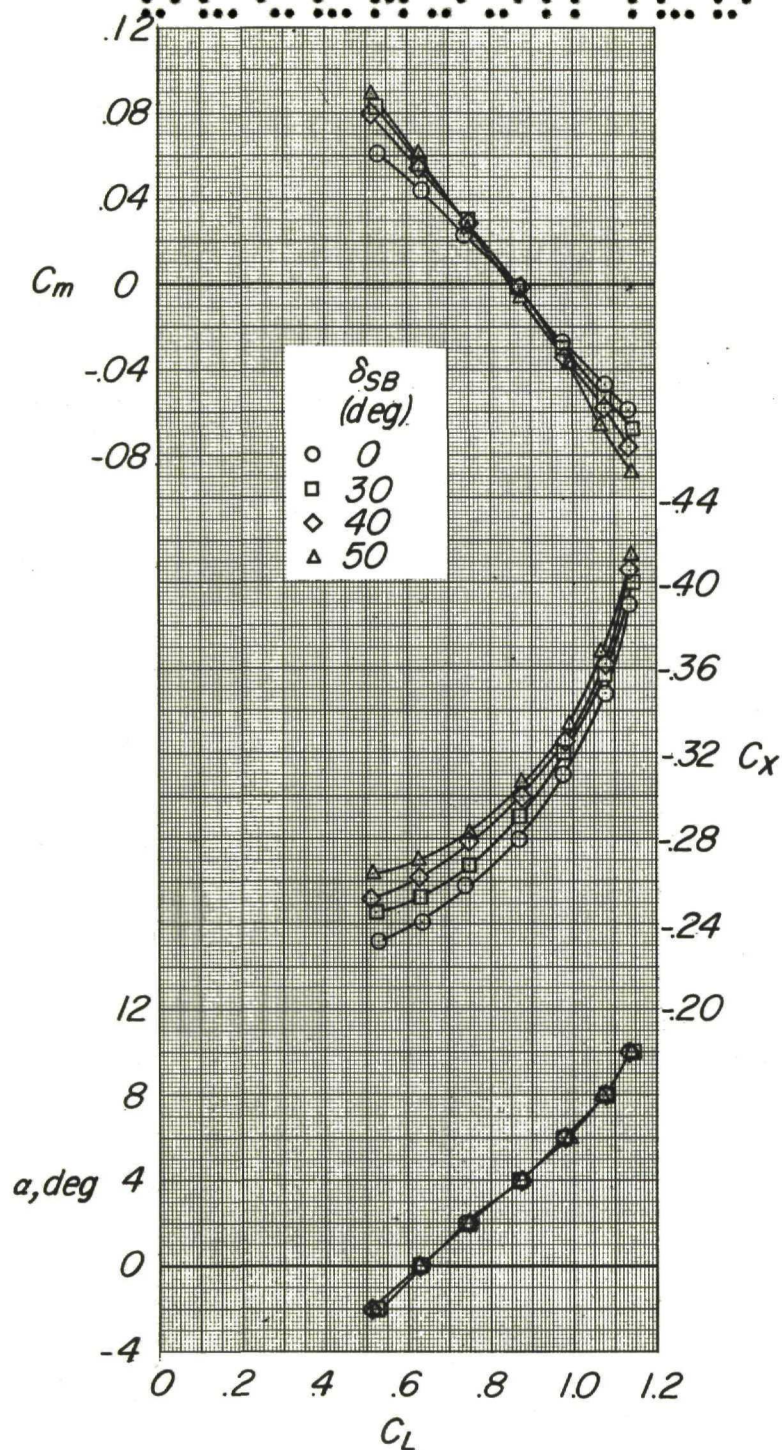
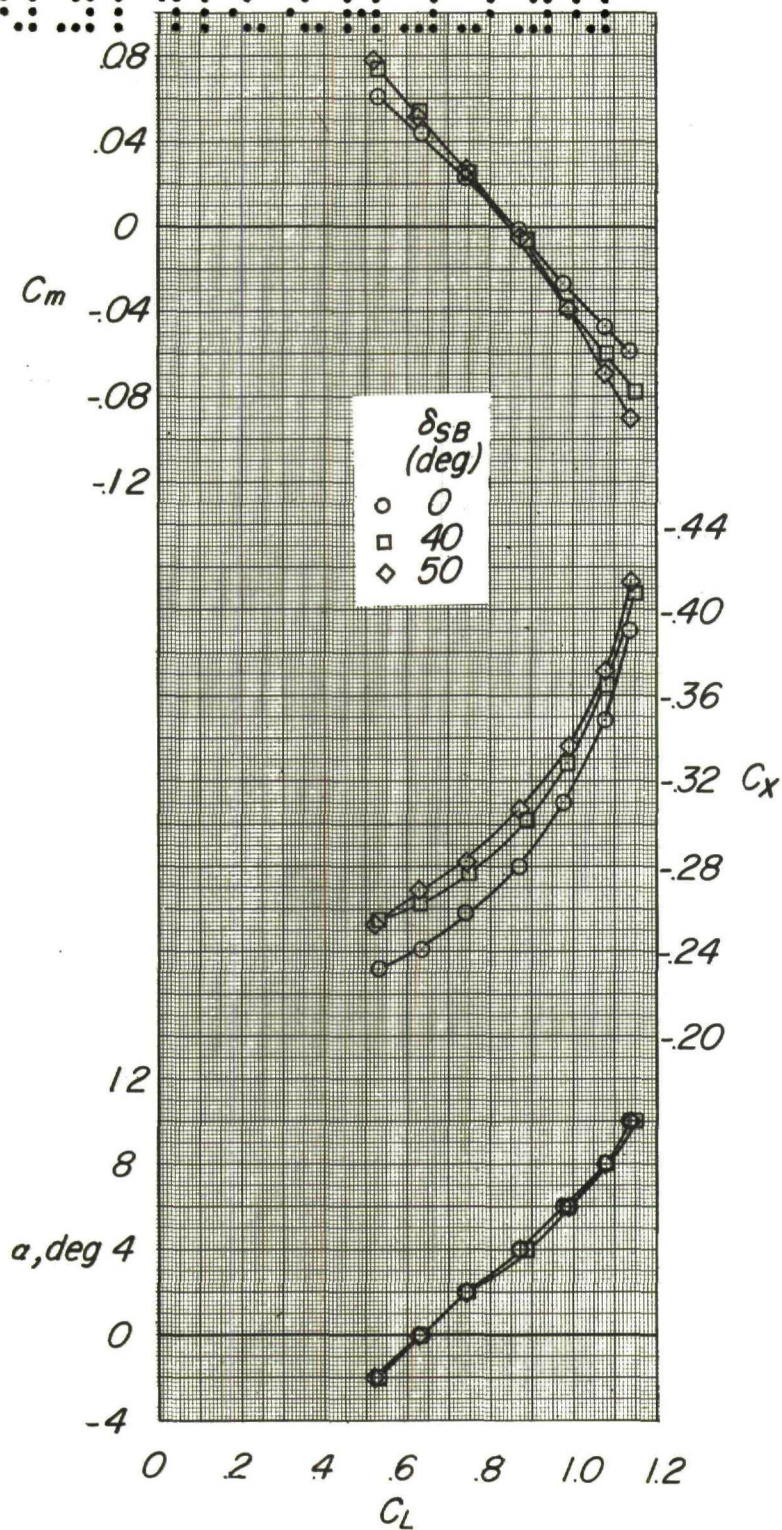


Figure 11.- Concluded.



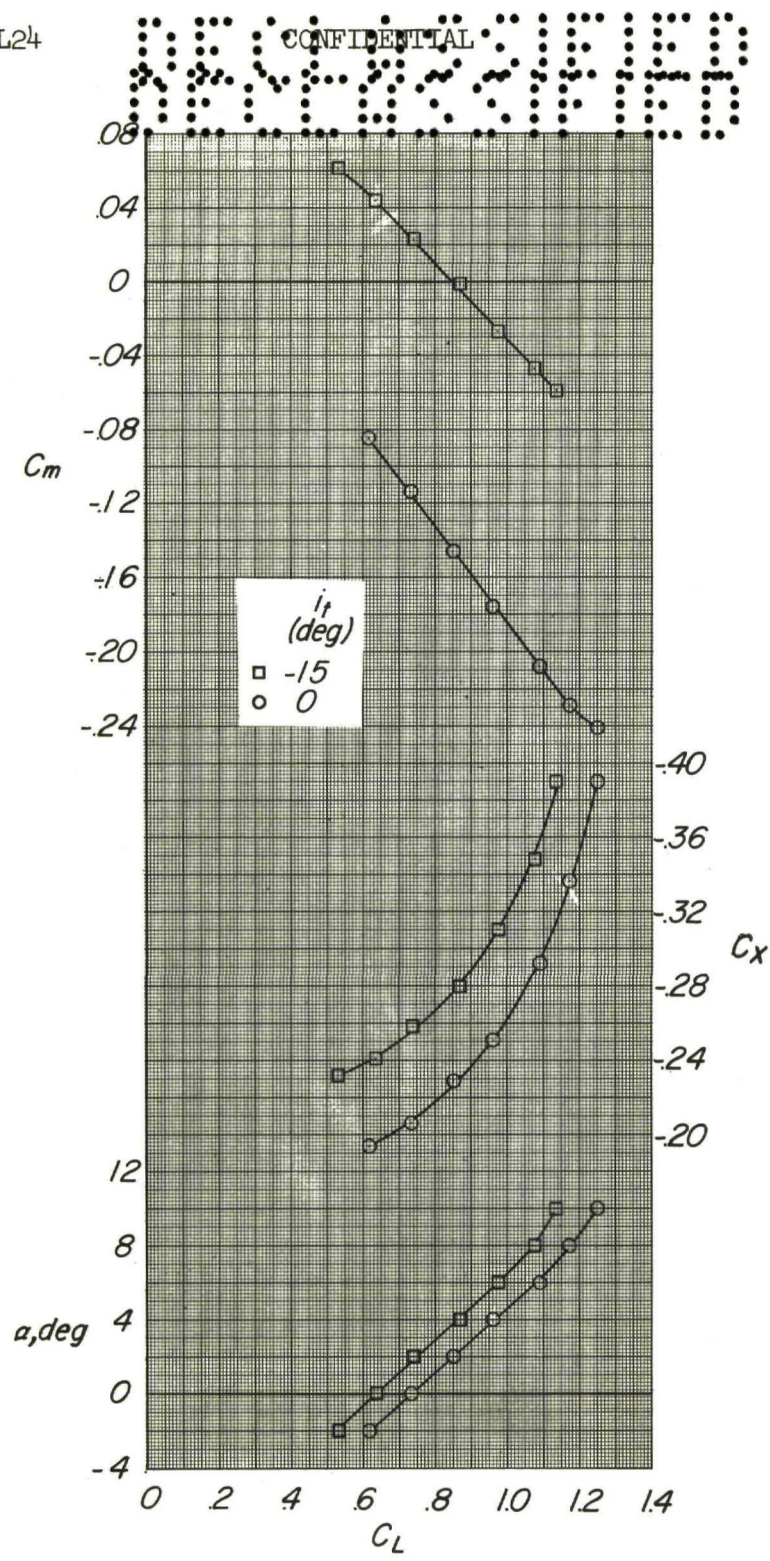
(a) Forward position of brake.

Figure 12.- The effect of speed-brake deflection on the aerodynamic characteristics in pitch in the presence of a ground board. Landing configuration; $\delta_f = 50^\circ$; $i_t = -15^\circ$; gap, 0.30 inch.



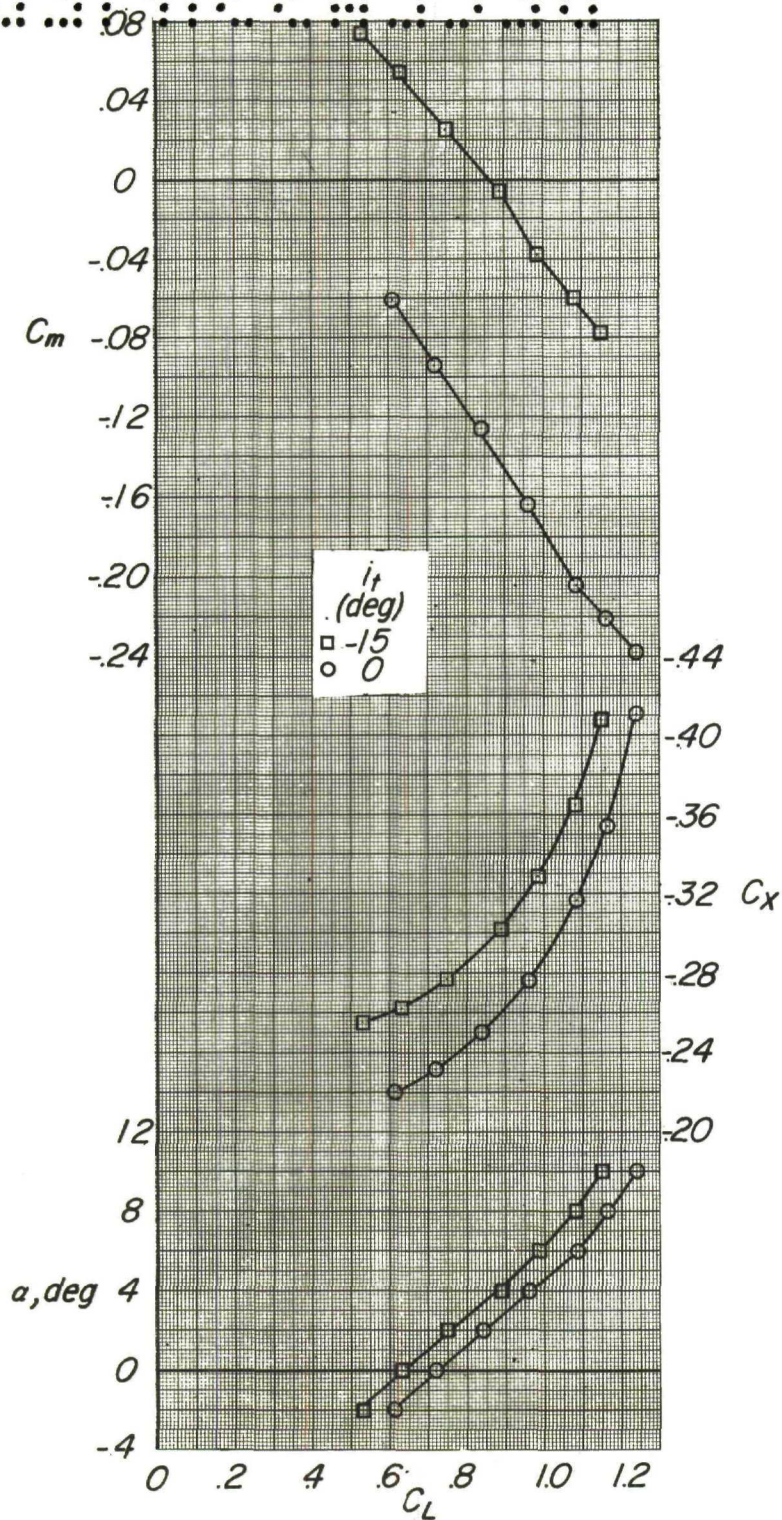
(b) Rearward position of brake.

Figure 12.- Concluded.



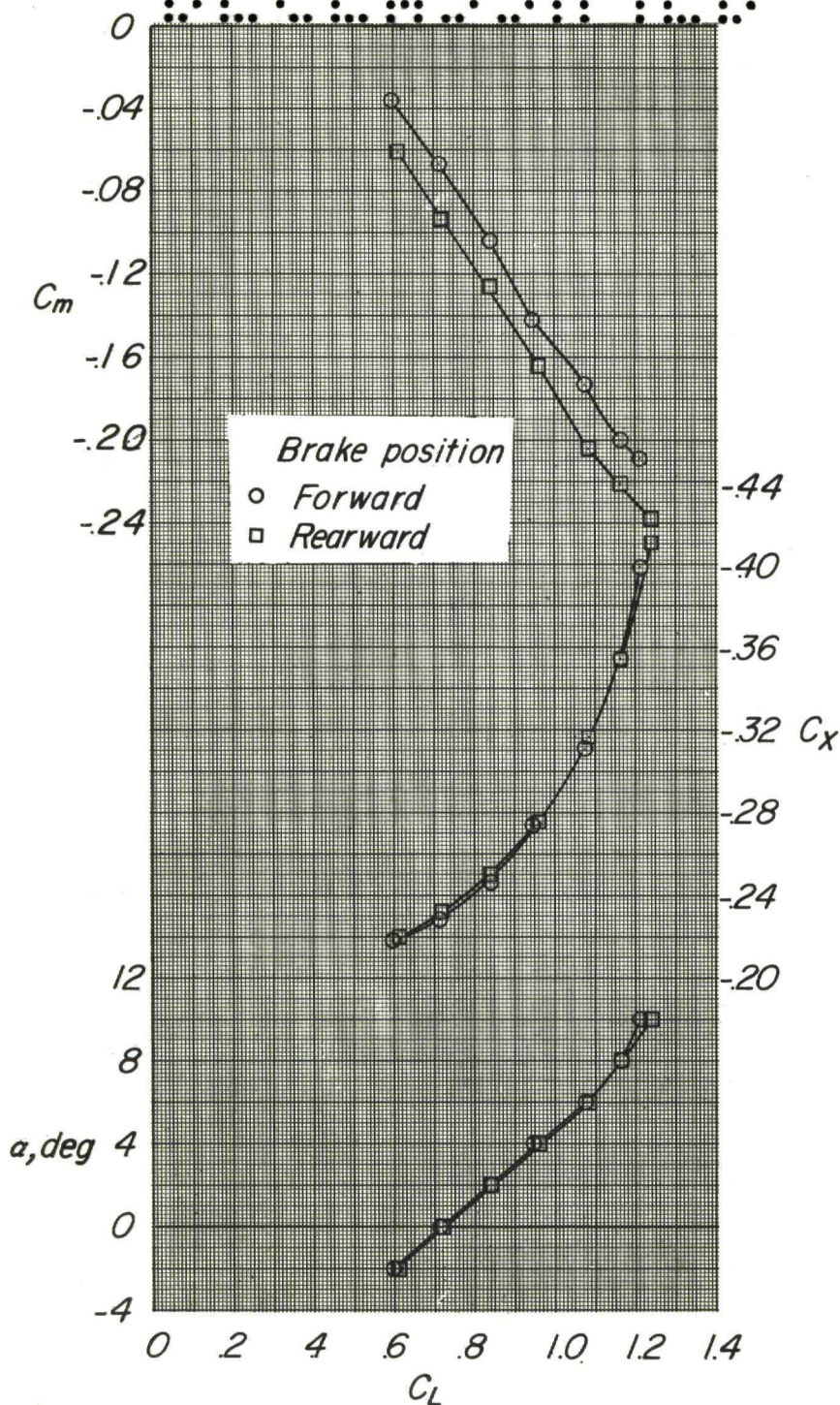
(a) $\delta_{SB} = 0^\circ$.

Figure 13.- The effect of horizontal stabilizer incidence on the aerodynamic characteristics in pitch in the presence of a ground board. Landing configuration; $\delta_f = 50^\circ$.



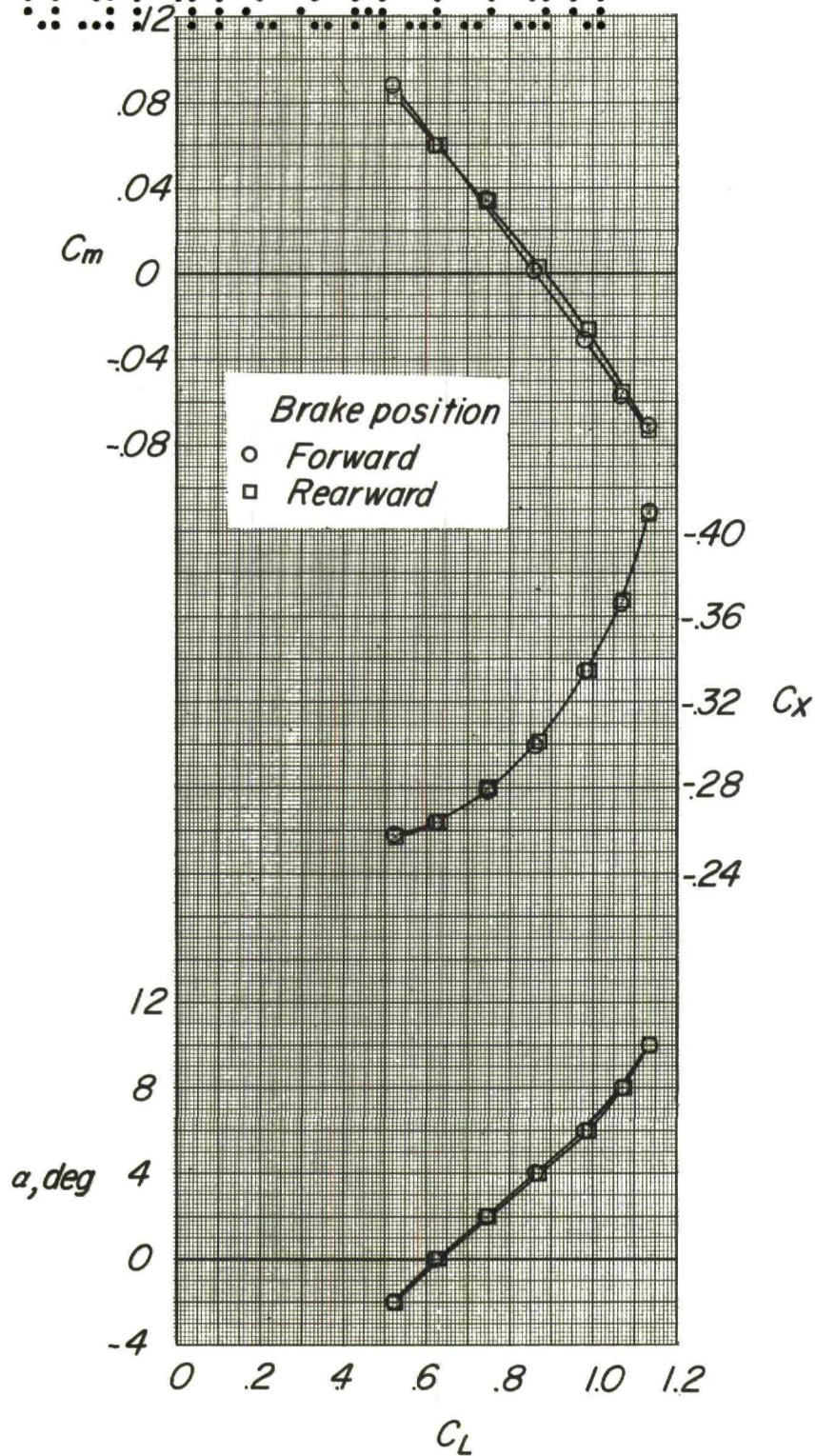
(b) $\delta_{SB} = 40^\circ$; rearward position; gap, 0.30 inch.

Figure 13.- Concluded.



(a) $i_t = 0^\circ$; gap, 0.30 inch.

Figure 14.- The effect of speed-brake position on the aerodynamic characteristics in pitch in the presence of a ground board. Landing configuration; $\delta_f = 50^\circ$; $\delta_{SB} = 40^\circ$.



(b) $i_t = -15^\circ$; gap, 0.60 inch.

Figure 14.- Concluded.

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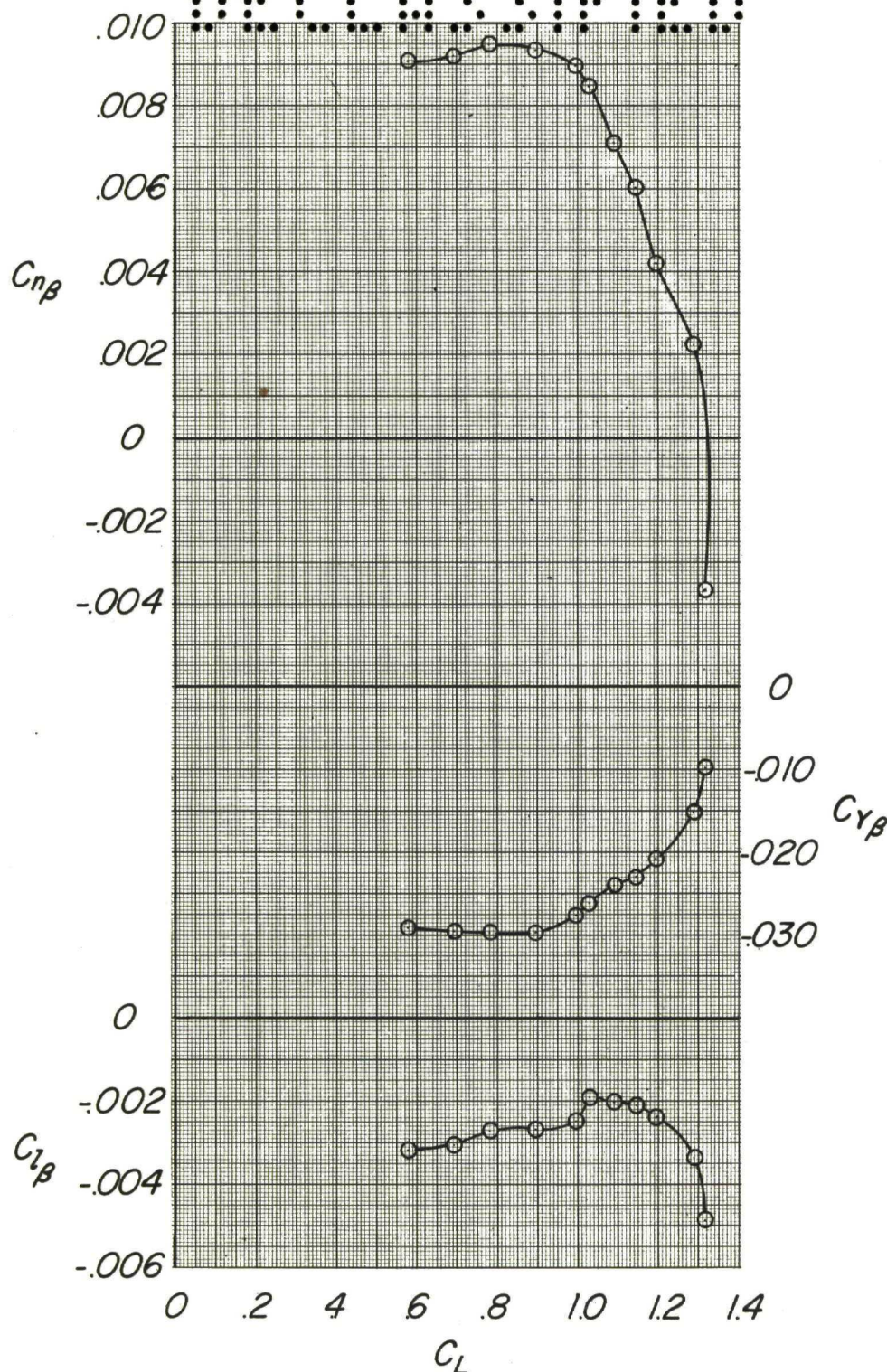


Figure 15.- The variation of the lateral stability parameters with lift coefficient. Landing configuration; $\delta_f = 50^\circ$; $i = 0^\circ$; $\delta_{SB} = 0^\circ$; notch sealed; fence off.

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